MACHINE DESIGN

November 1943

In This Issue:

Ideal Numbering System
Powder Metal Parts

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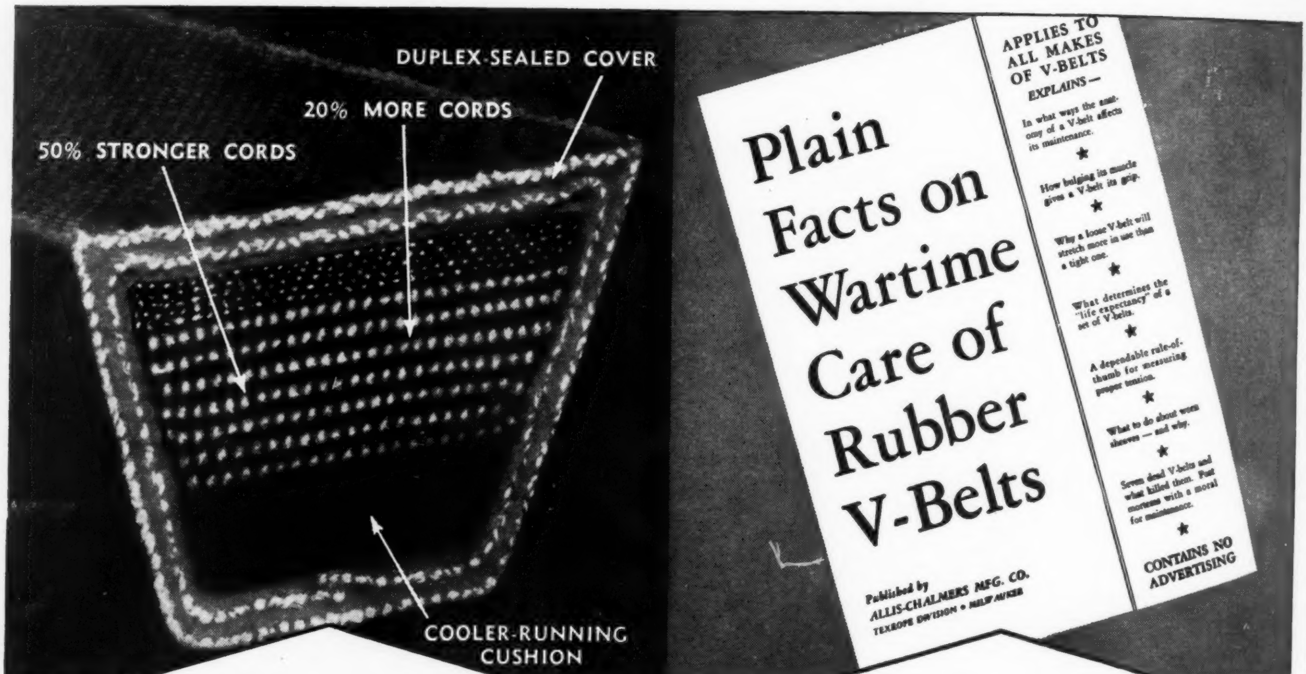

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MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

Volume 15 NOVEMBER, 1943 Number 11

Contents

For Itemized Table of Contents See Page 5

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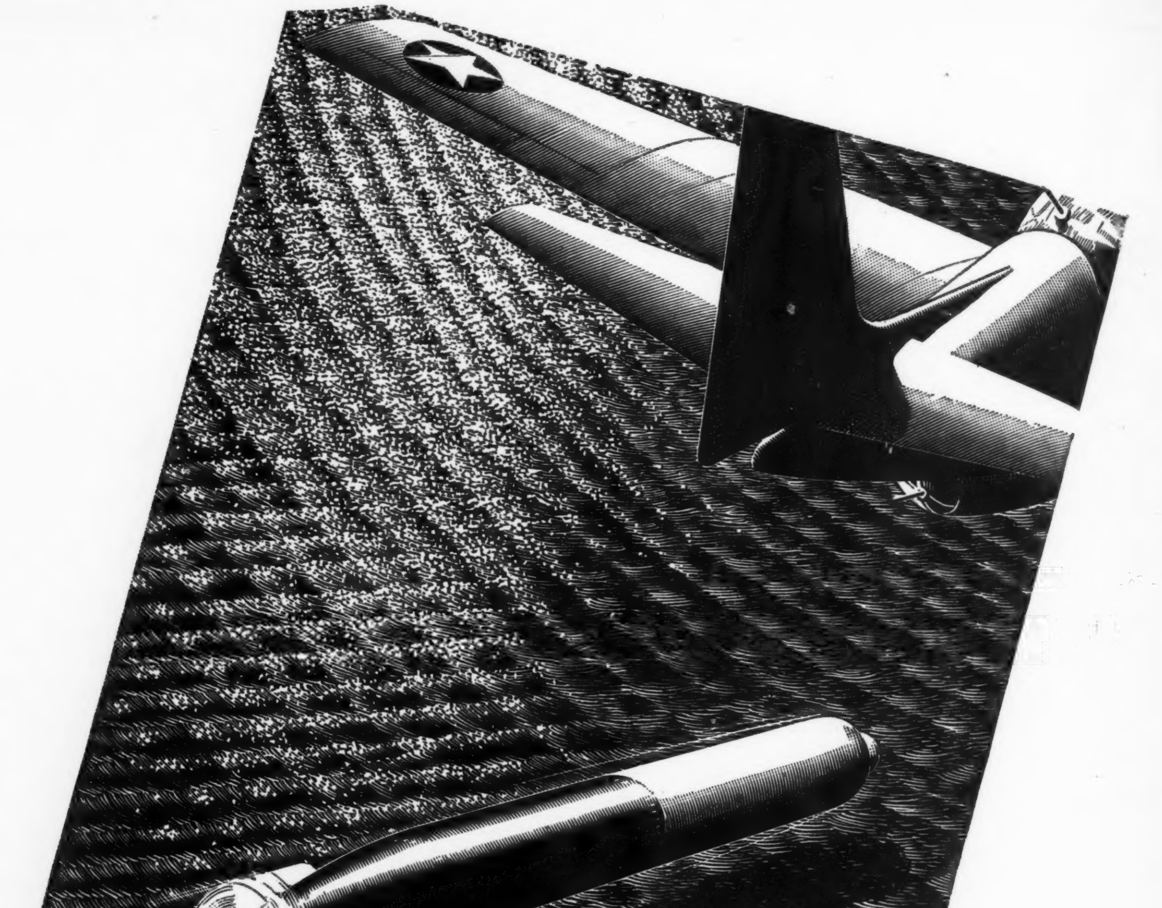

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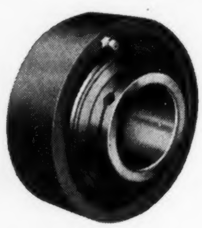

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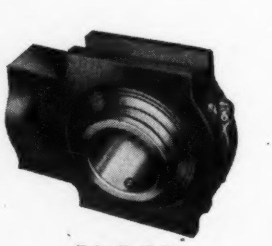

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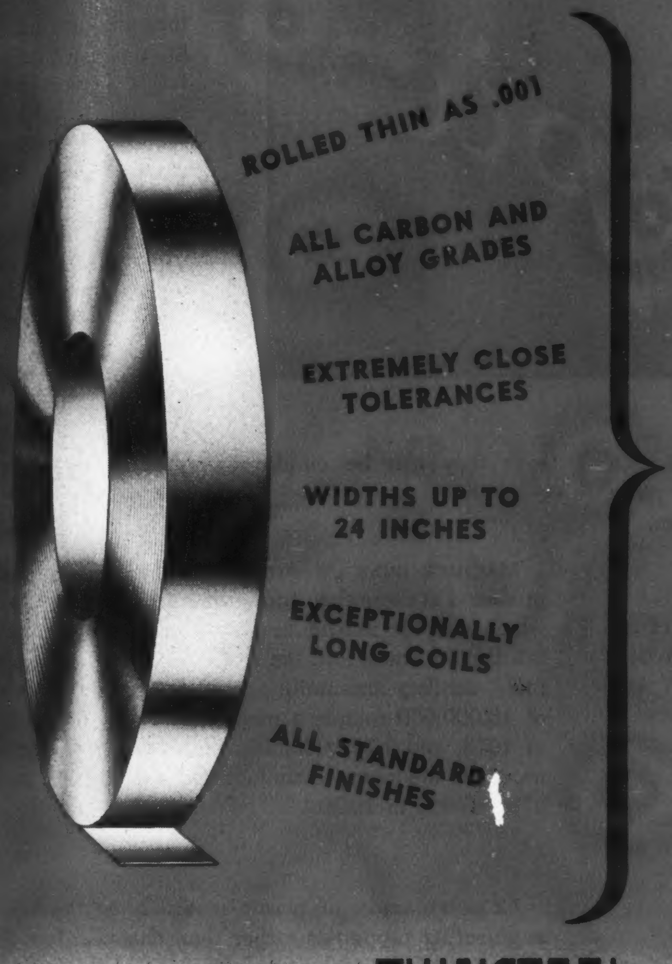

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Topics

PILOTS of 24 nations are receiving final combat training in American-made planes originally designed and built in 60 days to win an Army Air Force competition ten years ago. Experience gained in creating this trainer was employed advantageously to design and produce the first model of the Mustang fighter in 100 days from drafting board to flying field. Basic trainers are fitted with guns, bombs, cameras, and virtually every other piece of equipment a combat pilot must learn to operate.

CURTISS P-40 fighters have taken 13½ to 1 toll of the enemy, based on authoritative figures from 50 recent aerial engagements in which 457 fighters met 1257 Axis aircraft of all types on every war front.

STANDARDIZATION of aircooled gas engines has reduced the number of basic models by 50 per cent and the number of repair parts by 40 per cent.

WOMEN working in the aircraft industry constitute about one-third of the employes in this field. It is expected the figure will rise to at least 50 per cent by the end of the year.

TRAIL BLAZER for welding aircraft parts and light-gage materials literally knocks electrons off the atoms of gas in the air surrounding the joint to be welded so that the welding current is stabilized. The device, developed by Westinghouse, is an assembly of coils, condensers, transformers and a spark-gap oscillator.

COUNTING a multitude of tiny parts such as miniature jewel bearings is a time-consuming job. General Electric therefore has devised a tray with 1000 holes in the bottom for this purpose. Shaking the tray loaded with bearings lodges one in each recess. A slide opens the hole bottoms, discharging a dependable count.

OPERATING COMMITTEE on aircraft materials conservation will coordinate the activities of the Army Air Forces, Navy Bureau of Aeronautics and Aircraft Resources Control office in cooperation with the aircraft industry to replace manufacturing processes resulting in excessive waste of materials, manpower and facilities with more efficient and economical methods. Use of castings, stampings, forgings, hot pressing, preforming, welding and other high production methods will be encouraged wherever they can be employed profitably by industry.

MACHINE GUNS for Army Ordnance are now being produced at more than triple the rate of 22,000 a month which was the maximum produced in this country for the United States and the Allies in 1918. Correspondingly, artillery ammunition is being produced at a rate of 18,000,000 rounds a month compared to 2,700,000 in 1918, and 1,778,000,000 rounds of small arms ammunition are being manufactured each month against 278,000,000 in 1918.

CLASSIFICATION of plastic materials on the basis of engineering properties rather than chemical base is an objective of the technical committee of the Society of the Plastics Industry. It is felt that when the new classification is made available, design engineers will be more likely to specify plastics than without such information. This work is to be the beginning of a handbook of authoritative information on design criteria and recommended practices for the molding and fabricating of all plastic materials.

SPOT-CHECK by WPB on the use of cellulose plastics revealed that 14 molders with a capacity of 1,500,000 pounds per month placed orders in excess of 4,000,000 pounds for October. Because companies should not place orders for any month in excess of their capacity, each company received total denials. With equitable distribution it is felt there should be sufficient material so that it can be made available for good civilian usages.

COPPER and copper base alloy limitations have been eased somewhat through WPB allowing the use of these materials for certain automotive parts. These include the following: Thermostats, pressure-type radiator sealing caps, tube fittings for hydraulic systems, oil lines and fuel lines as well as shut-off cocks and valves for safety-type auxiliary fuel tanks.

Does Your NUMBERING SYSTEM Need Revamping?

By Roe T. Soule
Head, Engineering Organization Division
Taylor Instrument Companies

In any manufacturing organization, particularly if the equipment produced is of a mechanical nature, catalog numbers and part numbers often are considered as necessary evils. Perhaps one reason why efficient numbering is troublesome lies in the fact that whereas the product has been most carefully designed, the number plan may not have received the same treatment.

It is true that consecutive numbers assigned in numerical sequence to parts, assemblies and finished product will serve the bare purpose of identification. Such plans are of course in wide use. However, they do not in any way describe the product nor give any clue as to the manner in which one item differs from another. Furthermore, when consecutive numbers are used for both the finished product and the individual parts or for either, no definite means is inherent in the number for distinguishing catalog items from parts nor for indicating to what finished product the parts belong.

It is an accepted premise that a system of numbering which would at once indicate the kind and type of the finished product, the nature of the parts and subassemblies, and the product on which parts exclusive to it are used, would be of outstanding advantage. Such advantage would be found to extend to all parts of the organization from sales to design, production and manufacturing departments as well as to the trade and ultimate purchaser.

BECAUSE criticisms of existing methods for numbering machine parts, subassemblies and catalog items is frequently heard, MACHINE DESIGN takes pleasure in presenting the accompanying discussion of a unified numbering system, based on extensive research, which already has proved its worth. Number and letter combinations assigned to items carry a significance which conveys to those concerned specific information about the item and where it belongs. Design executives will find worthwhile ideas in this article which may help them improve their own systems

Such a system of catalog and part numbering has been actively employed by the Taylor Instrument Companies on its industrial indicating, recording and controlling instruments since 1934, and on parts and subassemblies for more than twenty years. This plan is known as the Unified Number System, or sometimes the Classified Number System. In this system, catalog numbers automatically classify and identify each instrument, which is also true of the numbers of the parts, and subassemblies.

It has been said that many things are "simply remarkable" until they are understood, whereupon they become "remarkably simple". Such is in fact true in the case of the unified number system. It is simply a series of classifications from which the data are selected to compile either catalog numbers or part and subassembly numbers.

CATALOG NUMBERS: In the case of catalog numbers of sales items the line is first divided into classes,

each being designated by a letter symbol, as for example:

Letter Symbol	Class of Product
E	Industrial Mercury-in-Glass Thermometers
J	Recording Instruments
K	Dial Instruments
R	Controlling Instruments
V	Diaphragm Valves

Various styles of instruments within each group are then identified by a numeral placed before the letter. These numerals are assigned consecutively as new designs are added to the group. The numeral and the letter symbol constitute what is termed the "Key Number' since it designates the basic instrument. Illustrations are as follows:

Key No.	Basic Instrument
120R	Recording Controller
160R	Indicating Controller
145R	Time Schedule Controller
47K	6-inch Dial Thermometer
76J	Recording Instrument

To complete the catalog number, it now remains to add symbols to indicate such features as actuation, number of pens or pointers, type of bulbs, fittings, etc., which are selected from established classification sheets.

Actuation is covered by a letter symbol which is termed the "second letter" since it always follows the letter of the key number. A standardized code of such symbols is maintained, examples of which are as follows:

Second Letter	Actuation
M	Mercury
V	Vapor
G	Gas
F	Pressure

The first numeral following the letters indicates the number of pens and type of service, etc., an example applying to one class of instruments being as follows:

First Numeral Following Letters	Number of Pens and Service
1	Single Duty, Single Record
2	Double Duty, Bi-record
3	Single Duty, Bi-record

The two remaining numerals cover the type of bulb and fittings. Standardized sheets are maintained listing all of the regularly cataloged bulb (temperature-sensitive element) forms and fittings. From these sheets the following samples have been selected from columns headed "For Tube System Type Instruments":

Termination Numerals	Bulb and Fittings
17	Plain Bulb with Flange
23	Union Connection Bulb with ¾-inch Separable Bushing
24	Union Connection Bulb with Flange
35	Plain Pressure Fitting

Fig. 1—Identifying part number of an instrument link by reference to group file

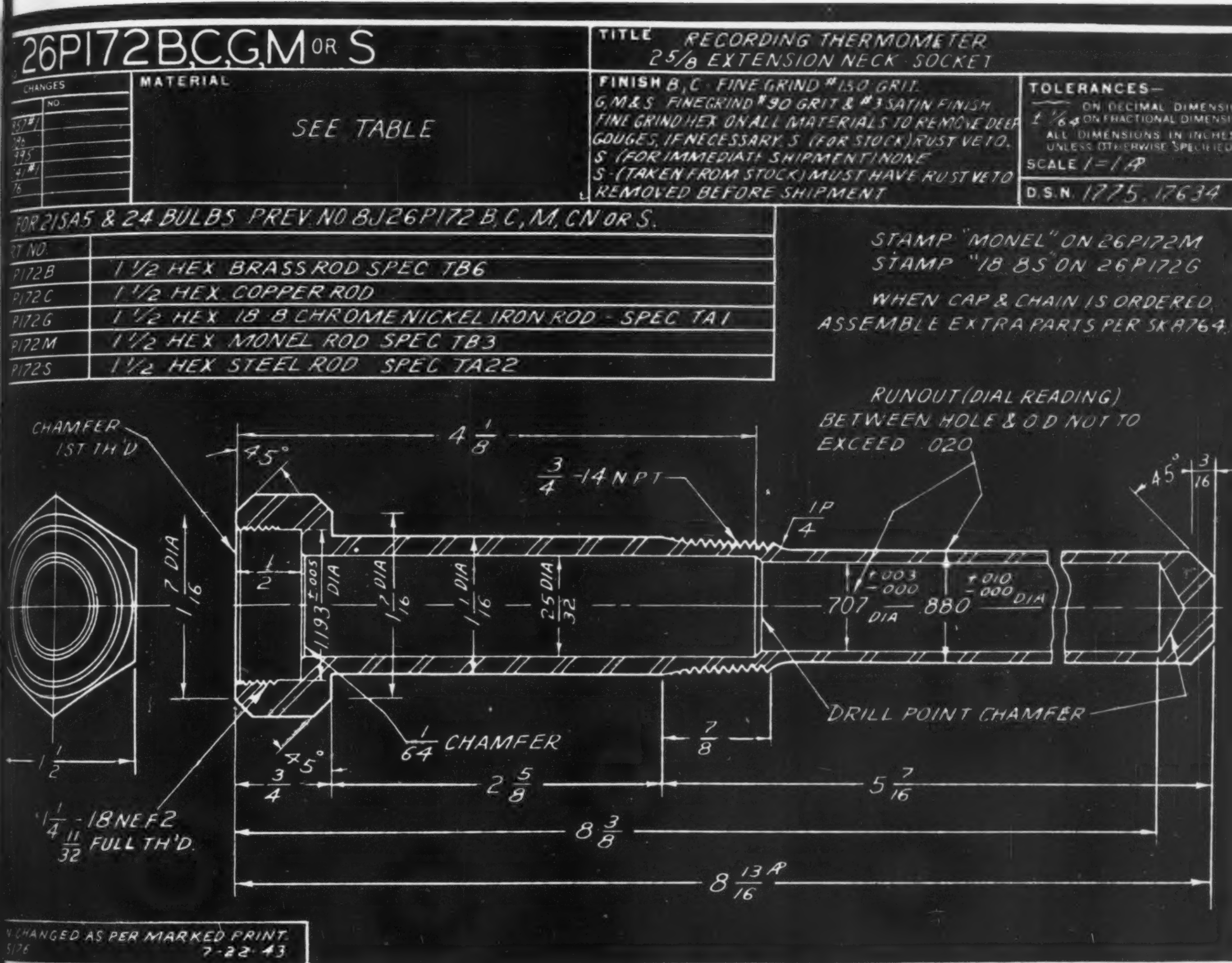


Fig. 2—Shows application of part numbers to the drawing of a socket which can be made in five different materials

A typical catalog number 120RM123, compiled in this manner, may be readily interpreted as a Recording Controller (120R), Mercury Actuated (M), Single Duty, Single Record (1), with Union Connection Bulb, having ¾-inch Separable Bushing (23).

As an authentic reference for compiling catalog numbers and also as an authoritative source of approved combinations, all of the foregoing data which apply to a given instrument series are listed on a sheet known as a Catalog Number Schedule Sheet. From this sheet and the sheet of standard termination numerals for bulbs, fittings, etc., the catalog number for any approved instrument in the series may be compiled. Also in similar manner any given catalog number may be interpreted by reference to the sheet. A catalog number schedule sheet is prepared when a new instrument is introduced, selections being made from existing classifications, or new ones developed as necessary to suit the product. Books of these sheets are maintained by all departments having occasion to use or interpret catalog numbers.

Extension of the system thus far described, which has applied to tube system type temperature instruments and to pressure instruments is readily accomplished. For example, the same 120R Recording Controller may be used for the control of flow or liquid level, thus utilizing manometers or floats instead of temperature-sensitive bulbs. Reference to the catalog number schedule sheet shows that under Actuation other second letters are provided to suit this requirement as follows:

Second Letter	Actuation
D	Differential Pressure
Q	Float

The same first numeral following the letters applies as in previous cases, but obviously the two final termination numerals must designate manometers and their ranges, floats, etc., rather than bulbs and fittings. Referring again to the sheet of standardized termination numerals, the following are selected from columns headed "For Manometer or Float Type Instruments":

Termination Numerals	Manometer or Float
16	Mercury Manometer 100 inches Water
59	Aneroid Manometer 200 inches Water
87	Buoyancy Type Level Unit 14 inches

It should be noted that the same numerals may indicate

either bulbs or manometers, depending upon which of the two corresponding columns on the Termination Numeral Sheet was used in selecting the numerals. The second letter of the catalog number automatically directs the column from which the numerals are to be selected. By this means twice the number of terminations may be possible without using more than two digits.

The catalog number for a recording flow controller employing an aneroid manometer, based upon the foregoing, would be 120RD159. Brief consideration will indicate the large number of possible instrument combinations for which the 120R Recording Controller may be supplied with a definite catalog number clearly identifying each specific instrument. Comparison with the many consecutive numbers which would be required to cover these related instrument forms, and the difficulty in endeavoring to have such consecutive numbers clearly identify the various combinations, emphasizes the flexibility of the unified catalog number plan, particularly for a product which is furnished in many different combinations of basic features.

Versatility of Plan Demonstrated

The unified catalog number plan is applied with equal facility to instruments such as time cycle controllers or industrial mercury-in-glass thermometers, neither of which employ tube systems or manometers. Catalog number schedule sheets issued for these instruments enable a person with only short acquaintance with the workings of the plan to compile or interpret the catalog numbers for literally thousands of instrument combinations.

Unified catalog numbers are readily adapted to statistical tabulation by electrical tabulating equipment using the Hollerith type cards. The classification feature lends itself conveniently to the analysis of production and sales data applying to an interrelated line of many varieties of product. Expansion of the line and new models are easily accommodated and succeeding designs of instruments are identified without difficulty even though the tradename may remain unchanged.

PART AND SUBASSEMBLY NUMBERS: Leaving for the time being, the discussion of catalog numbers of completed products, attention is now directed to the numbering of the parts and subassemblies used in the product. For this purpose a companion classified plan is employed which identifies the items and, where desirable, indicates the finished product on which they are used.

Part Classification Based on Function

All parts which are used in the assembly of instruments comprising the line are classified by name based upon the function of the part. Each classification is assigned a number comprised in most cases of one or two numerals and a letter. These classification numerals start at 0 and run to slightly above 100. In the case of single parts the letter is "P". Where two or more parts become a subassembly, the letter is "S". Within each classification the individual parts or subassemblies are numbered consecutively, such consecutive number being preceded by the classification number and letter symbol.

Examples of the part and subassembly classifications showing the classification symbols and the names of the parts in the respective classifications are shown as follows:

Part Classification Symbols	Names of Parts	Subassembly Classification Symbols	Names of Subassemblies
2P	Cases & Clock Boxes	2S	Case & Clock Box Subassemblies
10P	Cams	10S	Cam Subassemblies
21P	Bulbs (metal)	21S	Bulb Subassemblies
35P	Caps	35S	Cap Subassemblies
63P	Pointers	63S	Pointer Subassemblies

Standardized sheets listing these part and subassembly classifications both numerically and alphabetically are maintained for ready reference. It will be noted that the classification numeral is the same for parts and for subassemblies of the same name, the letter "P" or "S" designating those respective groups. The parts within each "P" group and within each "S" group are numbered consecutively beginning with 1. Numbers of actual parts and subassemblies illustrating the features discussed thus far are shown below:

35P177	Cap for Damping Unit
35S32	Cap Subassembly for Low Pressure Unit
63P155	Pointer for 6-inch Dial Thermometer
63S85	Set Pointer Subassembly

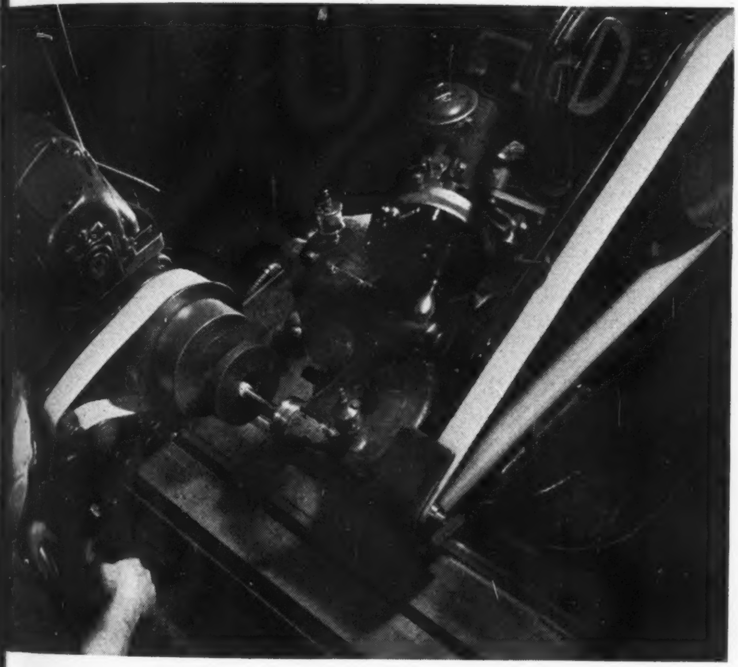
Where parts are made in several different materials or finishes but are dimensionally the same, letter suffixes are added to indicate such materials or finishes. Within any single group of parts the letter suffixes are standardized as far as practicable, a given letter always meaning the same material for that group. This is quite possible since as a rule a particular part is seldom if ever made from too great a number of materials to tax the available letters. This is also true with finishes. However, it is not expected that a letter suffix will always carry the same meaning when used with parts of different classifications. The following part numbers apply to parts made in more than one material or finish:

26P172B	Socket, Brass
26P172C	Socket, Copper
26P172G	Socket, Chrome-Nickel-Iron
26P172M	Socket, Monel
26P172S	Socket, Steel
2P381A	White Case for 8-inch Dial Thermometer
2P381B	Black Case for 8-inch Dial Thermometer

A further use of the letter suffix is to distinguish between a casting as obtained from the foundry and the part as later machined in the machine shop. In this case the letter suffix, which is usually selected from the last letters of the alphabet, indicates that the part is a casting only and must be machined. When the machining is accomplished the suffix letter is dropped. Of course if the part may be made in two materials, the castings would each carry a different suffix such as "X" and "Y" which would upon machining be replaced by suffixes such as

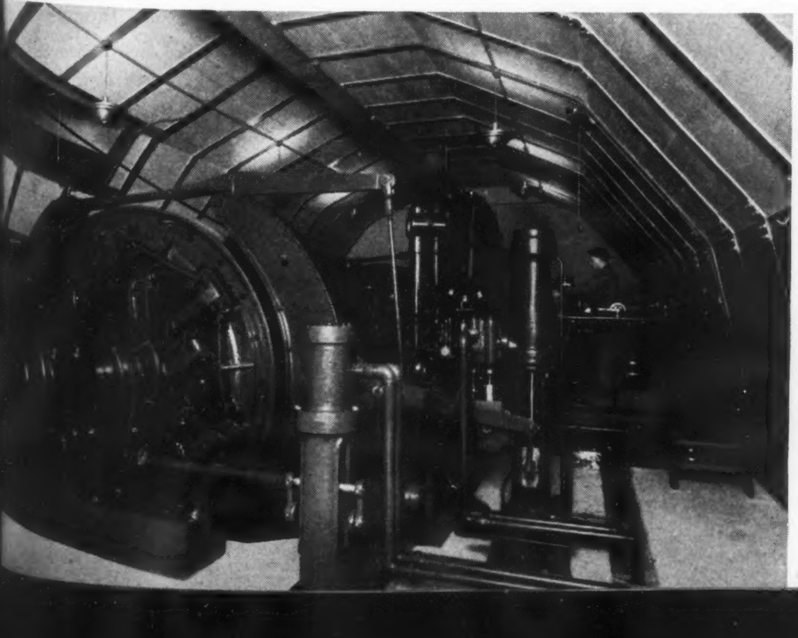
(*Continued on Page* 216)

Scanning the field for IDEAS



SPLICING fabric for high-speed, flat-belt drives facilitates the designers' problems on many applications where endless belts cause assembly obstacles. Also the facility and economy with which belts may be produced from stock belting may prove advantageous, especially for custom-built machines. The method of splicing was developed by Westinghouse and is applicable only to cotton belting with an "inner bound" weave. Such belts, left, have outperformed other types and outlasted some as much as ten times. Using no critical materials, belts from two to eight-ply in sizes from ⅜ to 84 inches in width can readily be cemented without the use of special tools or expensive equipment. If necessary, actual splicing can be done direct on the machine where the belt is to be used.

Procedure is similar to the method used for splicing leather and rubber belts. Ends are tapered to a feather edge with each ply being step cut. Ends are prime coated with a solvent and cement solution. After drying, a sheet of cement which has been immersed in the solvent is placed between the belt ends, securely clamped and allowed to dry. At room temperature 4-ply belt will dry in 15 minutes.



Metallic lead as a lubricant is particularly useful for heavily loaded, open gears on hoisting machines such as shown at left, electric locomotives, ball mills and ore-roasting machinery. When applied in the form of a fine powder (maximum size being 100 mesh with 85 per cent passing a 325 mesh screen) mixed in a high-viscosity grease, pressures do not squeeze out the lubricant nor does centrifugal force

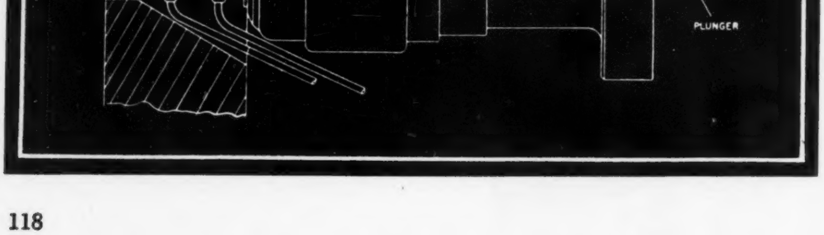
throw it from the gear teeth. Being amorphous and soft, the lead will not attach itself to two metallic surfaces in contact. Scratches or pits, however, in the surfaces are filled with lead and a film of the "greasy" metal protects the meshing teeth while providing lubrication.

Lead powder is also effective for lubricating low-speed, high-pressure open bearings by using 10 per cent of powder by weight in a nonemulsifiable grease similar to a No. 4 cup type. This has given excellent service on the lower tumbler bearing of gold dredges in set-ups which are not rubber sealed. One set of such bushings has been in service for more than three years. The lead actually plated the bronze, with no indications of wear on either the shaft or bushings. For extra-heavy pressures, 25 per cent powder is used and has been tested to give film strengths of over 40,000 pounds per square inch.

Friction cutting has many advantages as a production method when engineers find themselves limited in designing a given part due to the lack of facilities for fabrication. The machine for this process, developed by Arthur A. Schwartz of the Bell Aircraft Corp. and shown at right, is essentially a conventional metal-cutting bandsaw redesigned sufficiently to operate with 36-inch solid steel wheels which provide a band speed of about 12,000 feet per minute as compared with usual metal cutting speeds of 100 to 500 feet per minute. Blades are ordinary high-carbon steel such as employed for woodworking, having 8 to 14 teeth per inch and with a temper slightly on the soft side of usual spring temper.

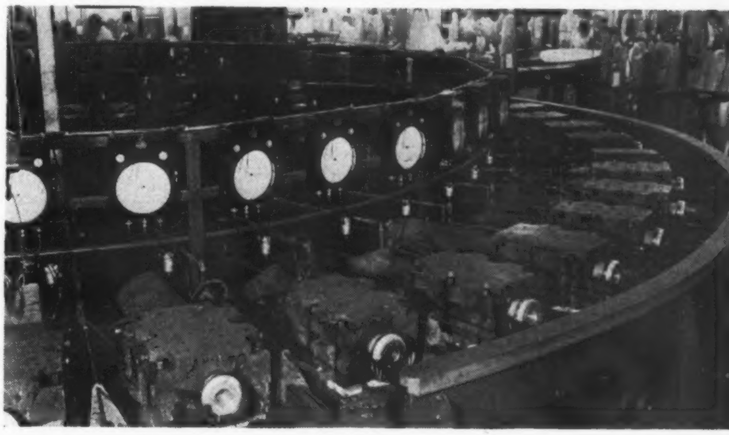
In running at 12,000 feet per minute, the saw generates sufficient heat through the sliding action of the teeth to melt the metal but without affecting the structure of the material as in the case of ordinary metal bandsaw cutting. Important advantage of this method lies in the fact that it is not necessary to hold the work solidly against the saw bed during cutting. So slight is the resistance of the metal to the speeding saw blade that the operator may freely manipulate odd shapes in cutting irregular patterns.

In addition to regular production cutting of aluminum steel, numerous experiments have been carried out which will intrigue designers. For example, the maker of a new and extremely tough laminated plastic still in the "secret" stage found the best that coult be done with a carbide tipped saw was to make an 18-inch cut in material 1½ inches thick. At that point the saw failed. With the friction method the same cut was made without damage to the saw. In another test, rings were cut from a glass tube. Armour plate may be cut at the rate of about 14 inches per minute. By way of citing disadvantages, materials such as soft rubber however, cannot be cut since loading occurs immediately, making sawing impossible.



Jet molding of thermosetting plastics produces extremely dense molded parts that are free from porosity, apparently resulting from the high temperatures employed. Intricate parts with thin sections and complicated inserts may be produced rapidly with uniform quality and full-rated strength. Jet molding may be accomplished with a standard injection molding machine for thermoplastics by using a conversion unit as shown at left which has been developed by Plastic Proc-

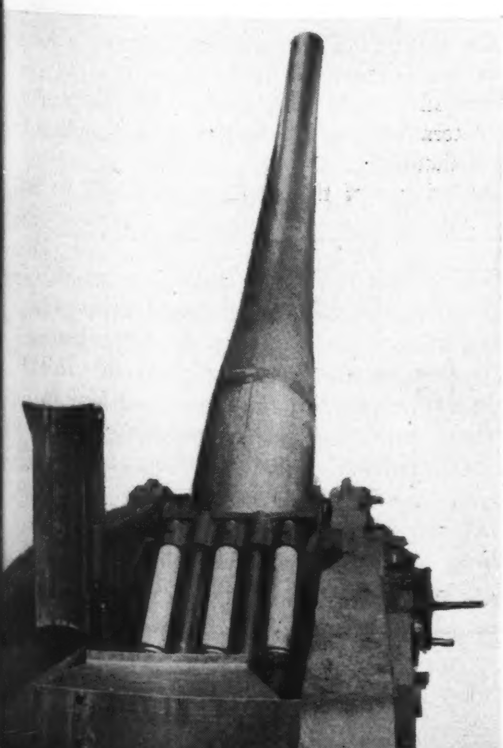
esses, Inc. Material is moved forward by a plunger that is cooled to prevent the material from softening and building up on the plunger. Then the material is forced through a preheating zone having a temperature between 150 and 190 degrees Fahr. which is below the heat-hardening range of the plastic. As the material passes through the injection nozzle it is flash heated to temperatures between 400 and 1200 degrees depending on the nature of the material and the requirements of molding. In this highly fluid state the charge is ejected into the mold in a fine stream. Circulating water in the heating tips prevents transfers of heat from the nozzle to the cylinder or mold. Material which solidifies in the nozzle apparently is not polymerized because upon the application of subsequent heat it again flows.



Merry-go-round, forty feet in diameter, automatically cures rubber fairings on propeller blades as shown in the illustrations at right. Turning on rollers, the table has a flat outer rim divided into 42 separate sectors carrying half-ton molds. Each has its individual system of air, steam, water and electricity automatically controlled through cam-operated valves and pressure controllers. Main supply lines are brought in through the center of the turntable by swing joints and slip rings.

The machine cures two sets of 21 blades simultaneously. Each station starts at a loading point, rotates to a gap-type hydraulic press, then moves successively through a steam-heating cycle, a water-cooling cycle and finally to an unloading point half way around the circle. Similar cycles are repeated on the other half. The turntable is actuated by a pneumatic ratchet drive from a 14-inch air cylinder, advancing a station every twelve minutes.

Blade has fairing built up by hand from molded pieces of sponge rubber and covered with sheets of uncured ebonite. This assembly is placed in the mold for curing. Turn of the table carries the mold under the hydraulic press which closes it under pressure. Mountings of the table near the presses are on steel springs so that there will be a slight give to bring the table into contact with the lower platen of the press while the press is being closed. After the pressure is released the table lifts, permitting the table to revolve to the next station. Design and construction of this unusual machine were carried out by L. Heres De Wyk Co. for Hamilton Standard Propellers Division of United Aircraft Corp.



Delicately balanced so that if power fails manual operation would be easy, the 16-inch gun at left utilizes a carriage which weighs over 250 tons with a 68-foot barrel weighing more than 100 tons. Pivoted on large trunnion bearings, the weight of the long rifle is counterbalanced by the massive breech assembly, powder chamber and recoil mechanism, while the heavy breech block also is balanced so that it can be swung open and closed by hand. A power-driven rammer facilitates loading. Built at Wellman Engineering Co., steel castings comprise a large part of the barbette carriages and stands required to support the barrel. Two ribbed side frames are the principal supporting members of the barrel and cradle. Bearings located near one end hold the cradle trunnions.

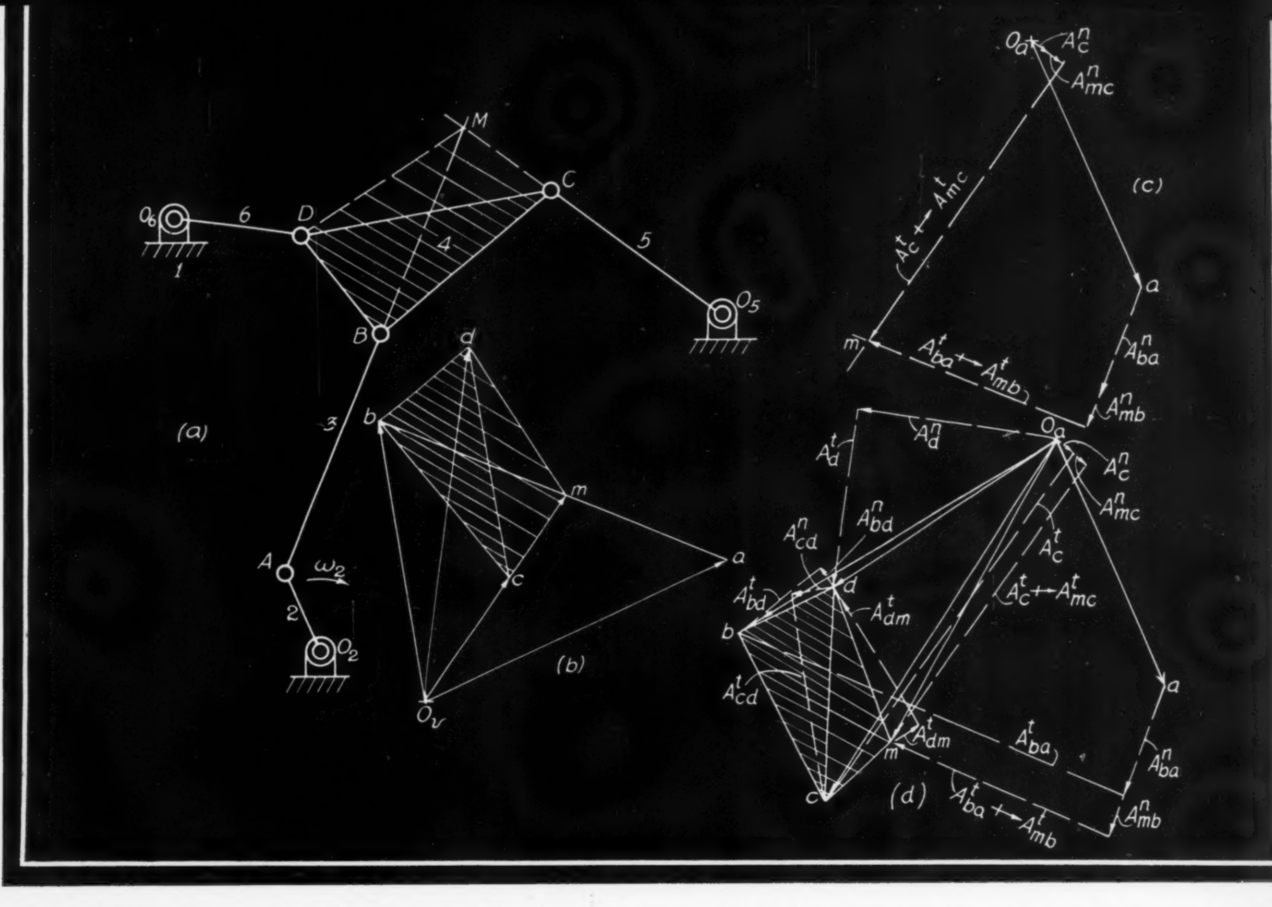


Fig. 1—Lack of knowledge of the motions of the junction points B, C and D of the floating link 4 makes impossible a direct step-by-step motion analysis of this mechanism. Use of the auxiliary point M makes such a solution possible

Auxiliary Points Aid Acceleration Analysis

By A. S. Hall and E. S. Ault
Purdue University

VELOCITY and acceleration analysis of a mechanism usually is a step-by-step process, beginning with the driving link and progressing from point to point through the mechanism. Frequently such a solution can be accomplished by writing and solving graphically the vector equations of motion for the points of junction between the links. However, occasions arise when this direct method is impossible because of inadequate knowledge of the motion of the junction points, hence some special method must be adopted.

A complex mechanism may contain one or more floating links—links which do not rotate about one fixed center or about a readily located instantaneous center. Link 4 of *Fig.* 1 is a floating link supported at three points *B*, *C* and *D* with the directions of motion of only two (*C* and *D*) immediately known. Such a mechanism does not yield readily to the point-by-point analysis and consequently requires special treatment. A convenient device to effect a ready solution in problems of this kind is the use of an *auxiliary point*. The auxiliary point is considered to be a part of the floating link and is at such a location that its velocity and acceleration can be determined by the point-to-point analysis. Once these values for the auxiliary point are determined the solution may be completed by the usual methods.

Selection and use of the auxiliary point will be illus-

POTENTIALITIES of "auxiliary points" as an aid to the solution of tough problems in motion analysis appear to have been overlooked by designers in general. This article explains what they are and how to use them and, taken in conjunction with previous articles on "How Acceleration Analysis Can Be Improved" (M.D. February and March, 1943), should go far toward bringing a somewhat theoretical subject into practical everyday use

trated first in the analysis of the characteristic mechanism of *Fig.* 1, in which the floating link 4 is supported at three points, *B*, *C* and *D*. The velocity solution is started by computing velocity of crankpin *A* on driving link 2:

$$V_a = [O_2A]\omega_2$$

This is represented by vector O_va drawn to a suitable scale from pole point O_v of the velocity polygon, *Fig.* 1 *b*.

Next the vector expression for the velocity of point *B* is written

$$V_b = V_a \mathrel{+\!\!\rightarrow} V_{ba} \quad \text{(1)}$$

The known quantities in this expression are the direction and magnitude of V_a and the direction (perpendicular to line *AB*) of V_{ba}, the velocity of *B* relative to *A*. This is not enough to determine V_b. Location of the instantaneous center of rotation of link 4 would show the direction of the velocity of *B* and enable the velocity solution to proceed. This instantaneous center of rotation (velocity) would be of no use, however, in the acceleration solution. What is needed instead is some point on link 4 whose velocity can be determined without recourse to instantaneous centers. Such a point is *M* on link 4 extended, located by extending links 3 and 5 to their intersection. *M* is not necessarily a point on the physical link but for the purpose of analysis it is permissible to think of link 4 extended to include point *M*. *M* is to be treated exactly as any other point on link 4, that is, it is rigidly connected to any other point such as *B* on link 4, and can move relative to *B* only in a direction perpendicular to line *MB*.

Velocity of *M* is

$$V_m = V_b \mathrel{+\!\!\rightarrow} V_{mb} \quad \text{(2)}$$

Substitution of the value of V_b from Equation 1 into Equation 2 gives:

$$V_m = V_a \mathrel{+\!\!\rightarrow} (V_{ba} \mathrel{+\!\!\rightarrow} V_{mb}) \quad \text{(3)}$$

in which the compound vector $(V_{ba} \mathrel{+\!\!\rightarrow} V_{mb})$ is directed normal to line *ABM* since V_{ba} is normal to *BA* and V_{mb} is normal to *MB*.

Velocity of *M* can be expressed also in terms of its velocity relative to point *C*:

$$V_m = (V_c \mathrel{+\!\!\rightarrow} V_{mc}) \quad \text{(4)}$$

in which the compound vector $(V_c \mathrel{+\!\!\rightarrow} V_{mc})$ is normal to O_5CM since V_c is normal to O_5C and V_{mc} is normal to *MC*. In other words, Equation 4 says that the velocity of auxiliary point *M* on link 4 is normal to O_5M.

Equation 3 can now be solved for V_m. In *Fig.* 1*b* a line is drawn through *a*, the tip of the V_a vector, in the direction of $(V_{ba} \mathrel{+\!\!\rightarrow} V_{mb})$. The intersection of this and a line through O_v in the direction of V_m as indicated by (4) locates *m*, the tip of the V_m vector.

Now that the velocity of one point on link 4 has been obtained the velocity polygon is easily completed. The necessary vector equations are as follows:

$$V_d \text{ (normal to } O_6D) = V_m \text{ (known) } \mathrel{+\!\!\rightarrow} V_{dm} \text{ (normal to } DM) \quad \text{(5)}$$

$$V_b \text{ (unknown) } = V_d \text{ (known) } \mathrel{+\!\!\rightarrow} V_{bd} \text{ (normal to } BD) \quad \text{(6)}$$

$$V_b \text{ (unknown) } = V_a \text{ (known) } \mathrel{+\!\!\rightarrow} V_{ba} \text{ (normal to } AB) \quad \text{(7)}$$

$$V_c \text{ (normal to } O_5C) = V_d \text{ (known) } \mathrel{+\!\!\rightarrow} V_{cd} \text{ (normal to } CD) \quad \text{(8)}$$

The acceleration solution follows the same outline as

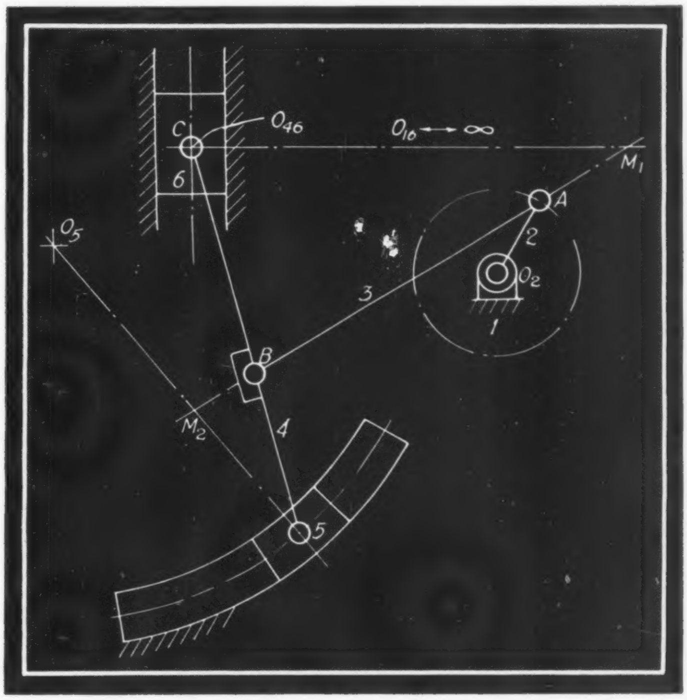
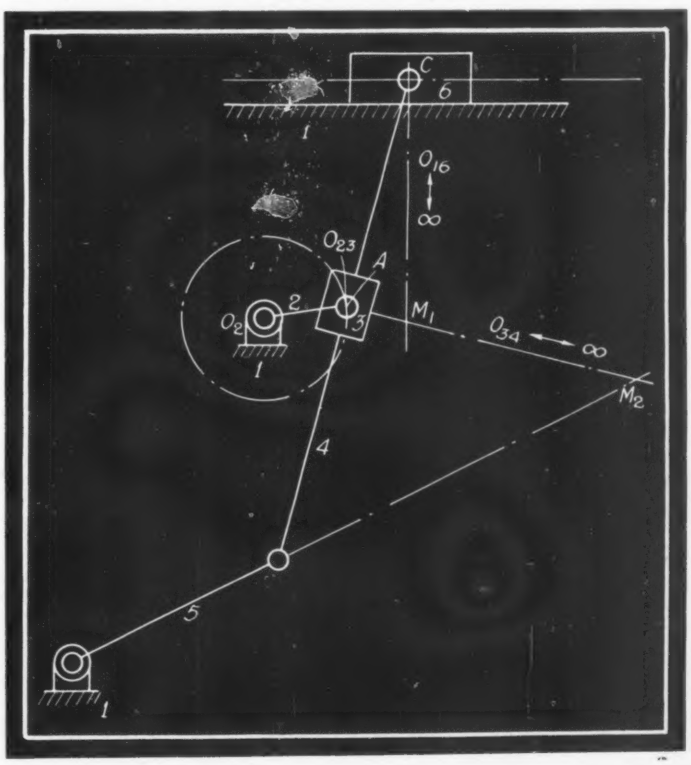


Fig. 2—Above—Variable-displacement pump mechanism employs floating link 4. Alternative locations of auxilary points are M_1 and M_2

Fig. 3—Below—Crank shaper mechanism has a floating link 4, auxiliary points for which may be at either M_1 or M_2



the velocity solution. If ω_2, the angular velocity of the driving crank, is constant, then $A_a = A^n_a = [O_2A]\omega_2^2$, direction A toward O_2. The acceleration polygon is started by drawing from pole point O_a the vector $O_a a$ to represent the computed value of A_a.

Next the acceleration of auxiliary point M on link 4 is determined by the following equations:

$$A_m = A_b \mathrel{+\!\!\!\!\rightarrow} A_{mb} = A_a \mathrel{+\!\!\!\!\rightarrow} A_{ba} \mathrel{+\!\!\!\!\rightarrow} A_{mb} \quad \ldots\ldots\ldots \quad (9)$$

also

$$A_m = A_c \mathrel{+\!\!\!\!\rightarrow} A_{mc} \quad \ldots\ldots\ldots \quad (10)$$

When the vectors of Equations 9 and 10 are separated into their normal and tangential components, the following equations result:

$$A_m = A_a \mathrel{+\!\!\!\!\rightarrow} A^n_{ba} \mathrel{+\!\!\!\!\rightarrow} A^t_{ba} \mathrel{+\!\!\!\!\rightarrow} A^n_{mb} \mathrel{+\!\!\!\!\rightarrow} A^t_{mb} \quad \ldots\ldots \quad (11)$$

and

$$A_m = A^n_c \mathrel{+\!\!\!\!\rightarrow} A^t_c \mathrel{+\!\!\!\!\rightarrow} A^n_{mc} \mathrel{+\!\!\!\!\rightarrow} A^t_{mc} \quad \ldots\ldots\ldots \quad (12)$$

In Equations 11 and 12, A_a is known, the normal components can be computed, and the tangential components are known in direction. Regrouping of the terms makes it evident that the two equations can be solved simultaneously for A_m:

$$A_m = A_a \mathrel{+\!\!\!\!\rightarrow} A^n_{ba} \mathrel{+\!\!\!\!\rightarrow} A^n_{mb} \mathrel{+\!\!\!\!\rightarrow} (A^t_{ba} \mathrel{+\!\!\!\!\rightarrow} A^t_{mb}) \quad \ldots \quad (13)$$

$$A_m = A^n_c \mathrel{+\!\!\!\!\rightarrow} A^n_{mc} \mathrel{+\!\!\!\!\rightarrow} (A^t_c \mathrel{+\!\!\!\!\rightarrow} A^t_{mc}) \quad \ldots\ldots\ldots \quad (14)$$

After the necessary velocities have been obtained from the velocity polygon and distances scaled from the drawing the following computations are made:

$A^n_{ba} = V_{ba}^2/[BA]$, directed from B toward A

$A^n_{mb} = V_{mb}^2/[MB]$, directed from M toward B

$A^n_c = V_c^2/[O_5C]$, directed from C toward O_5

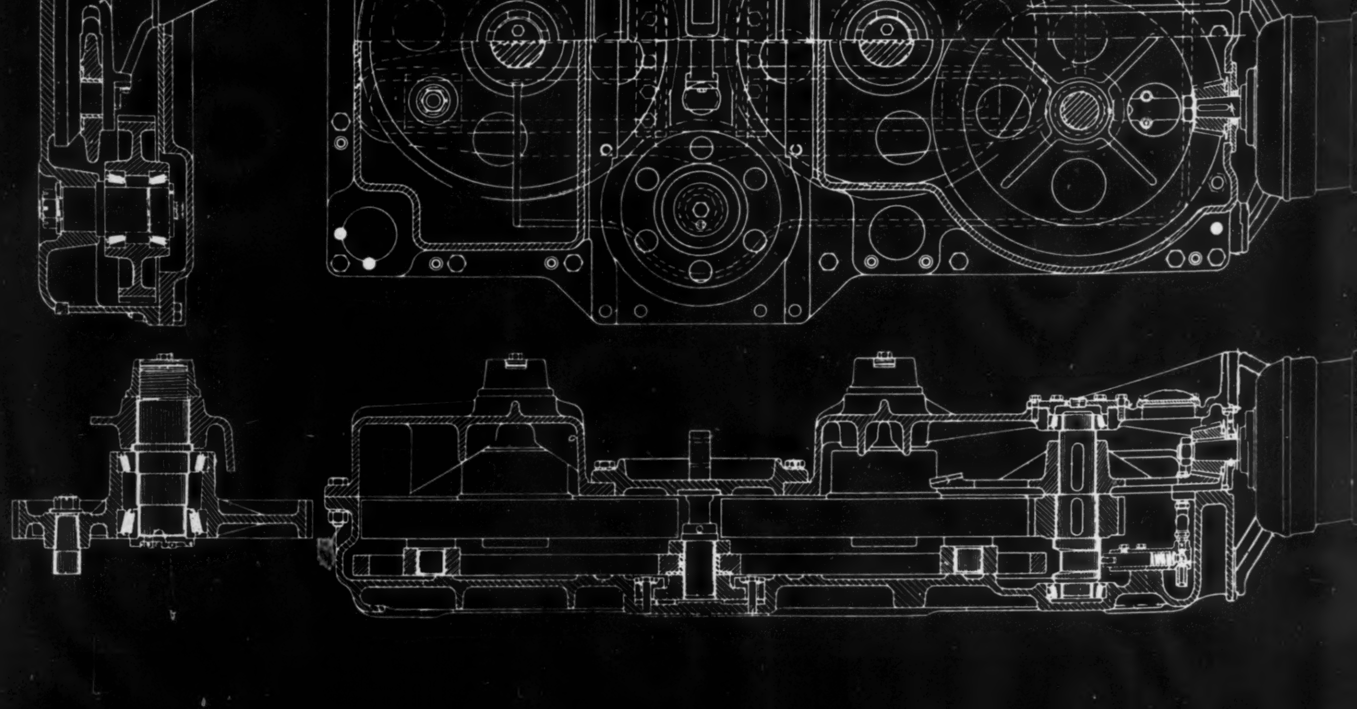
$A^n_{mc} = V_{mc}^2/[MC]$, directed from M toward C.

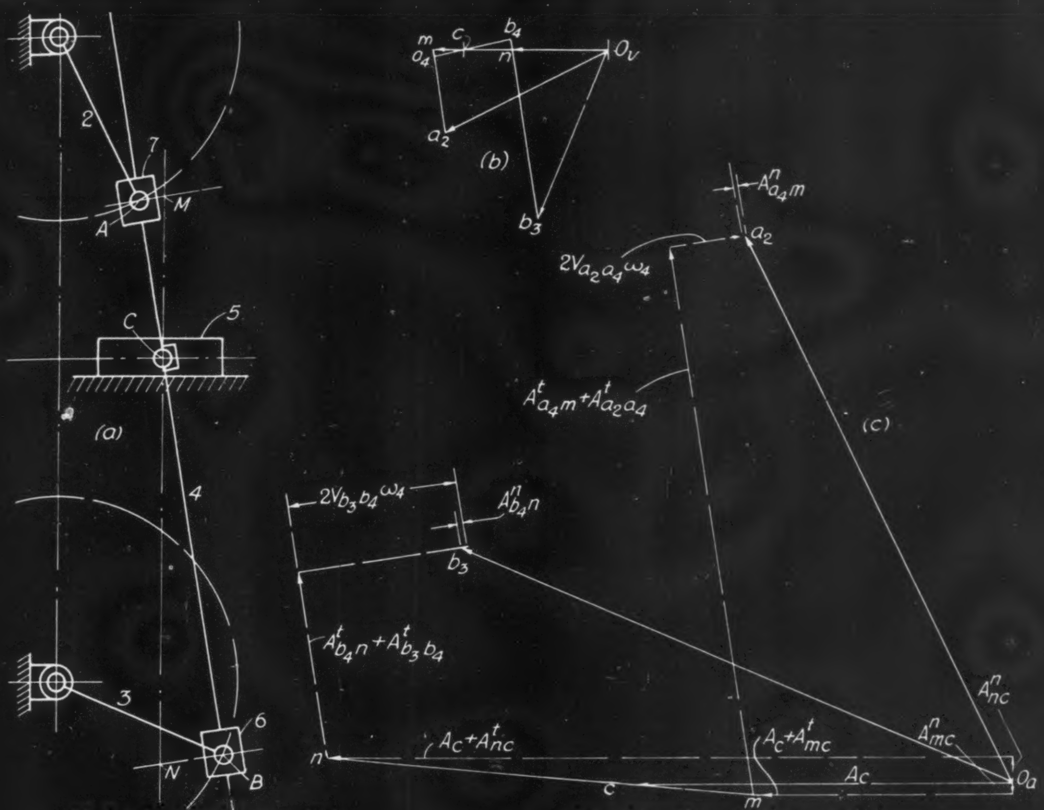
The compound vector $(A^t_{ba} \mathrel{+\!\!\!\!\rightarrow} A^t_{mb})$ is directed normal to line MBA since A^t_{ba} is normal to BA and A^t_{mb} is normal to MB. Likewise the vector $(A^t_c \mathrel{+\!\!\!\!\rightarrow} A^t_{mc})$ is normal to line MCO_5.

Solution for A_m is now completed by adding vectors in the acceleration polygon in accordance with Equations 13 and 14. To the tip of the A_a vector add A^n_{ba} and then A^n_{mb}. Through the tip of the A^n_{mb} vector draw a line in the direction of $(A^t_{ba} \mathrel{+\!\!\!\!\rightarrow} A^t_{mb})$. Starting back at the pole point O_a lay out A^n_c and add to it A^n_{mc}. Through the tip of the A^n_{mc} vector draw a line in the direction of $(A^t_c \mathrel{+\!\!\!\!\rightarrow} A^t_{mc})$. The intersection of this line and the line previously drawn in the direction of $(A^t_{ba} \mathrel{+\!\!\!\!\rightarrow} A^t_{mb})$ locates m, the tip of the A_m vector. The acceleration polygon at this stage is shown in *Fig.* 1c.

The acceleration polygon is completed by solving for the accelerations of points D, B, and C in accordance with the following equations, in each of which the normal components can be calculated from the velocities and dis-

Fig. 4—Shaker conveyor drive is example of a mechanism which requires auxiliary points for acceleration solution





Velocity Polygon (b)

M and N are auxiliary points on link 4. MCN vertical, BN and AM perpendicular to ACB.

1. $V_m = [V_c +\rightarrow V_{mc}]$ (horizontal)
2. $V_m = V_{a_2}$ (known) $+\rightarrow [V_{a_4a_2} +\rightarrow V_{ma_4}]$ (parallel to ACB)
3. $V_n = [V_c +\rightarrow V_{nc}]$ (horizontal)
4. $V_n = V_{b_3}$ (known) $+\rightarrow [V_{b_4b_3} +\rightarrow V_{nb_4}]$ (parallel to ACB)
5. $V_{cn}/V_{mn} = CN/MN$
6. $V_{a_4} = V_c +\rightarrow V_{a_4c}$ and $V_{a_4} = V_m +\rightarrow V_{a_4m}$
7. $V_{b_4} = V_c +\rightarrow V_{b_4c}$ and $V_{b_4} = V_n +\rightarrow V_{b_4n}$

Velocity polygon started at O_v

Scale from polygon and record values of: V_{a_4m} (distance a_4m to scale); V_{b_4n}; V_{mc}; V_{nc}; $V_{a_2a_4}$; $V_{b_3b_4}$.

Compute ω_4 (angular velocity of link 4).

Acceleration Polygon (c)

Start at O_a

1. $A_m = A_c +\rightarrow A_{mc}$
$= A_c +\rightarrow A^n_{mc} +\rightarrow A^t_{mc}$
$= A^n_{mc}$ (compute)
$+\rightarrow [A_c +\rightarrow A^t_{mc}]$ (horizontal)
2. $A_m = A_{a_2} \longrightarrow A_{a_4m} \longrightarrow A_{a_2a_4}$
$= A_{a_2} \longrightarrow A^n_{a_4m} \longrightarrow A^t_{a_4m}$
$\longrightarrow A^t_{a_2a_4} \longrightarrow 2V_{a_2a_4}\omega_4$
$= A_{a_2} \longrightarrow A^n_{a_4m} \longrightarrow 2V_{a_2a_4}\omega_4$ (compute)
$\longrightarrow [A^t_{a_4m} +\rightarrow A^t_{a_2a_4}]$ (parallel to ACB)
3. $A_n = A_c +\rightarrow A_{nc}$
$= A_c +\rightarrow A^n_{nc} +\rightarrow A^t_{nc}$
$= A^n_{nc}$ (compute)
$+\rightarrow [A_c +\rightarrow A^t_{nc}]$ (horizontal)
4. $A_n = A_{b_3} \longrightarrow A_{b_4n} \longrightarrow A_{b_3b_4}$
$= A_{b_3} \longrightarrow A^n_{b_4n} \longrightarrow A^t_{b_4n}$
$\longrightarrow A^t_{b_3b_4} \longrightarrow 2V_{b_3b_4}\omega_4$
$= A_{b_3} \longrightarrow A^n_{b_4n} \longrightarrow 2V_{b_3b_4}\omega_4$ (compute)
$\longrightarrow [A^t_{b_4n} +\rightarrow A^t_{b_3b_4}]$ (parallel to ACB)
5. $A_{cn}/A_{mn} = CN/MN$

Fig. 5—Velocity and acceleration solutions for double slider-crank mechanism in shaker conveyor drive, Fig. 4 are facilitated by use of tabulated equations

tances while directions of both normal and tangential components are known:

$$A_d = A_m +\rightarrow A^n_{dm} +\rightarrow A^t_{dm} \quad (15)$$

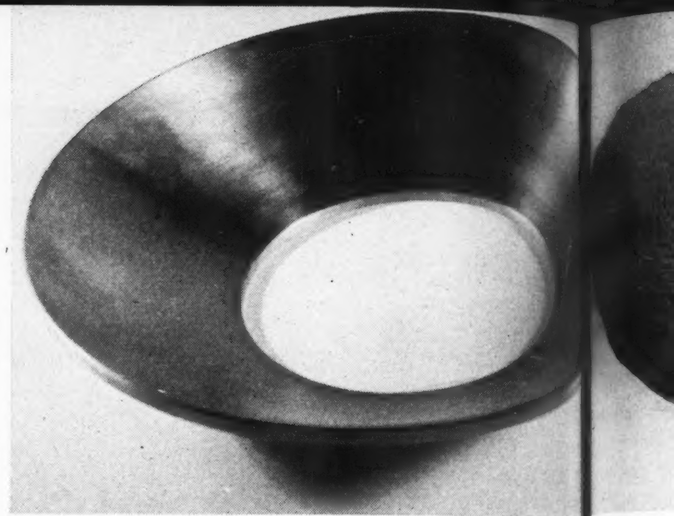
$$A_d = A^n_d +\rightarrow A^t_d \quad (16)$$

$$A_b = A_d +\rightarrow A^n_{bd} +\rightarrow A^t_{bd} \quad (17)$$

(Concluded on Page 234)

NEW as the latest bomber yet old as the Pyramids, powder metallurgy has received a tremendous impetus due to the war. It promises to emerge as a full-fledged industry and a healthy competitor of more widely used fabricating processes. Not only has the adoption of powder metal parts relieved many vital bottlenecks in materials and production facilities, it also has provided designers and producers with the "know-how" which will enable them to realize the full benefits of the process in the development of new parts.

Fig. 1—In 90 minutes production time the loose pile of metal powder at extreme right is transformed into the bronze war part at right



Originally devised for making things which could not be made by any other means—filaments for light bulbs, porous metal bearings, carbide cutting tools, etc.,—powder metallurgy technique has invaded other fields and now offers machine designers another alternative whenever a new or improved design is contemplated. Some of the factors that will influence the ultimate decision in a particular case are discussed in this article, in the hope that designers will thereby be aided in specifying and developing powder metal parts.

Designing Powd eta

By Colin Carmichael

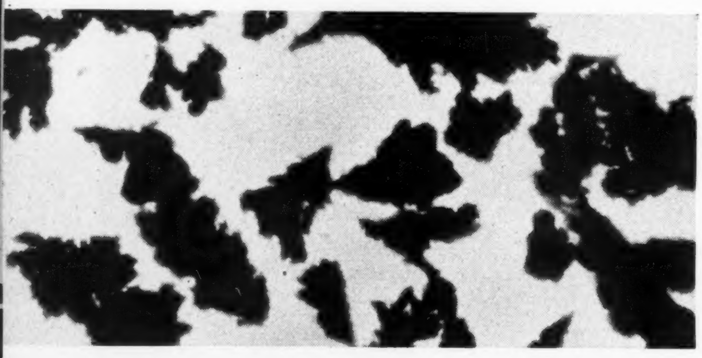


Fig. 2—Electrolytic copper powder, used in clutch and brake linings, looks like this under a microscope

Fig. 3—Below—Shows dies for briquetting powdered iron which will become a U-shaped magnet

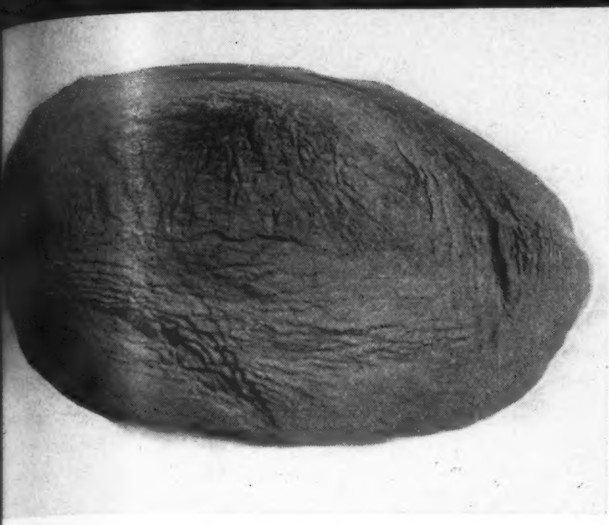
Because the process by which powder metal parts are made has been described frequently, only brief reference to production procedures is necessary. However, certain aspects of the process have a vital effect on design and warrant more than a passing reference. First the metal powders themselves are selected and blended, then screened. The powder mix is compressed or briquetted in a mold, *Fig.* 3, under pressure sufficient to form a self-sustaining compact which will withstand the necessary handling during transfer to the sintering furnace, *Fig.* 4. The sintering stage transforms the mass of powder into a hard metal comparable in strength to a casting. Following sintering the part may be sized in a coining press, or may even be machined if necessary.

Influence of Production Process on Design

Purity, size and shape of powder grains all influence the final properties of the part. Grain size of the sintered metal cannot be smaller than the powder grain size, but may be larger due to heat treating in the sintering furnace. Angular grains, *Fig.* 2, cohere well in the "green" compact, forming a self-sustaining piece, *Fig.* 4, without the use of a binder. Parts which are to be highly porous, such as filters and bearings, may employ a binder which vaporizes, burns or melts out during sintering.

Compression of the powder in the mold or die differs materially from the corresponding process in the case of forgings or plastic moldings because the dry powder has no plastic qualities and will not flow laterally under pressure. As a result there are limitations to the length of a piece that can be compacted to uniform density, and to the shape of the die, all cavities of which must be filled simply by pouring in the powder. Controlling factors in design due to these limitations will be discussed in detail later.

During sintering, the temperature may be sufficient to



etal Machine Parts

melt one of the metals present (but not the major constituent) and there may even be some alloying action. More often, the sintering temperature is below the melting point of any of the constituents, union of the particles being analogous to welding, with the result that the component metals retain their separate identities and characteristics. Nonmetals in powder form may also be included to give desired characteristics. This ability to produce new materials is one of the outstanding features of powder metallurgy, with possibilities of far-reaching significance.

Coining Increases Dimensional Accuracy

Parts as they emerge from the sintering furnace have somewhat the appearance of a smooth casting or forging, *Figs.* 5 and 8, and may be used in this form. Greater dimensional accuracy and smoother finish are obtained by subsequent sizing or coining, after which they are sufficiently accurate for most purposes. Tolerances of the order of .001-inch are possible if the cost is justified. Machining operations may also be carried out, using carbide tools, but it should be borne in mind that much of the advantage of the powder metal process over castings and forgings is lost if the part must also be machined. This of course holds true only for parts which are competitive and not for parts which can be made only by powder metallurgy.

Because of the many variables in selection and processing of the materials in powder metallurgy, it will be evident that properties of parts may be controlled within wide limits. The characteristic which most sharply differentiates powder metal parts from castings and forgings is density, which may be anything from 50 to 100 per cent of that of the "solid" metal. Strength, hardness, and certain other characteristics vary inversely with the density, the high-density materials closely resembling castings or forgings of the same composition. The micrographs in *Fig.* 6 illustrate this point clearly.

Density control is obtained in two ways—by mixing with the powder a material that burns or melts out during sintering, and by varying the briquetting pressure. Effect of briquetting pressure is particularly important in design because unless the part is proportioned so that the powder can be compacted with uniform density throughout the die, variations will occur in the sintered piece. If advantage is to be taken of the relatively intricate shapes obtainable by powder metallurgy, some sacrifice in uniformity may therefore be necessary unless additional die costs can be otherwise justified.

In the light of the foregoing it will be apparent that density, strength, hardness and other properties determined by tests on a specimen compacted as a plain cylindrical bar will be reproduced only in simple shapes and cannot be expected with more complicated designs. For this reason, strength and other values quoted for powder metal materials should not be taken too literally as design data.

It is of interest to note that in the recently issued U. S. Army Ordnance tentative specification AXS-1067, dated August 16, 1943, "Metal powder compacts, iron base for miscellaneous parts (except bearings)", the physical tests required are to be determined after consideration of the function which the part is to perform and are to be made on samples of the part itself. The new specification recognizes three types of materials:

Class A—Low density (5.4 grams per cubic centimeter minimum) with total carbon 2.5 per cent maximum. Material is described as similar to common cast iron, suitable for applications where the stresses are low. Tensile strength, determined on special subsize specimens, is approximately 15,000 pounds per

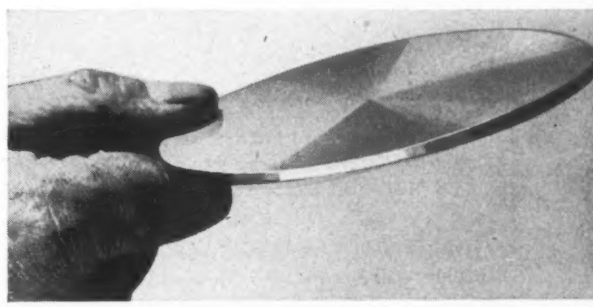
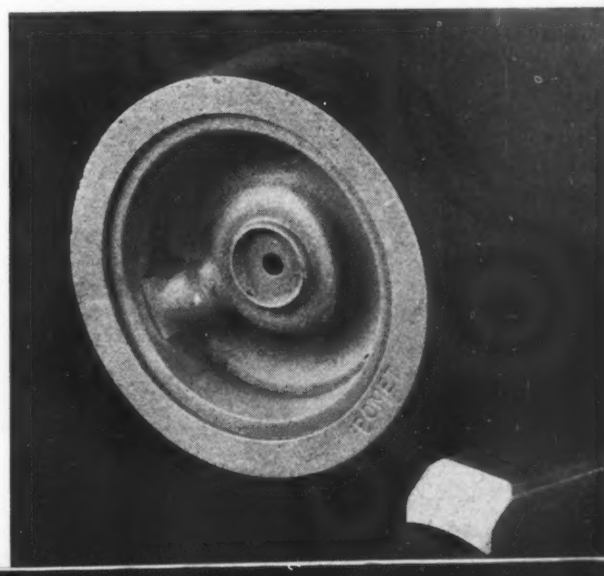


Fig. 4—Above—Strong cohesion of the dry metal powder after compacting is well illustrated by this photograph before sintering

Fig. 5—Below—These machine parts, the larger one of brass and the smaller one of low-carbon steel, have had no machining



square inch, with an elongation ½ per cent in one inch.

Class B—Medium density (5.8 grams per cubic centimeter minimum) with total carbon .4 per cent maximum. Material is similar to Class A but with higher tensile strength (25,000 pounds per square inch), a definite yield point, and appreciable elongation (3 per cent).

Class C—High density (6.5 grams per cubic centimeter minimum) with total carbon .2 per cent maximum. Material is described as having properties somewhat less than ordinary malleable iron, intended for application where stresses and impact are moderate. Tensile strength and elongation are approximately 35,000 pounds per square inch and 7 per cent, respectively.

Unless otherwise specified, parts are to be impregnated with a suitable rust-inhibiting oil, and may contain copper up to 35 per cent by weight.

In considering powder metal parts as possible alternatives for castings, forgings, etc., it should be borne in mind that the process is adapted primarily to the production of large quantities of identical pieces. It is, of course, necessary to have a new die for each different part. Die charges, as well as setting-up charges, are such that it is necessary to deal with production volumes of from 5000 to 50,000 pieces to warrant these charges.

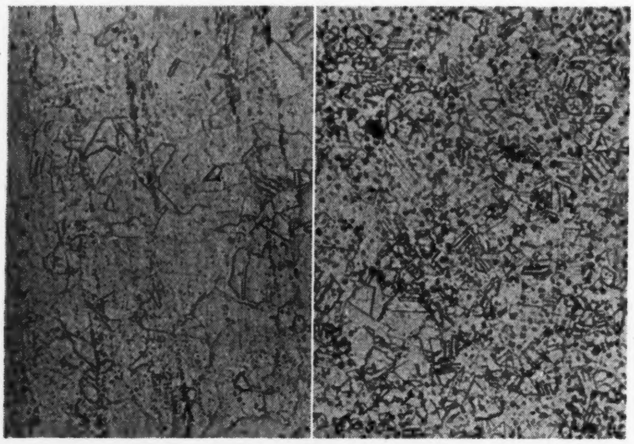
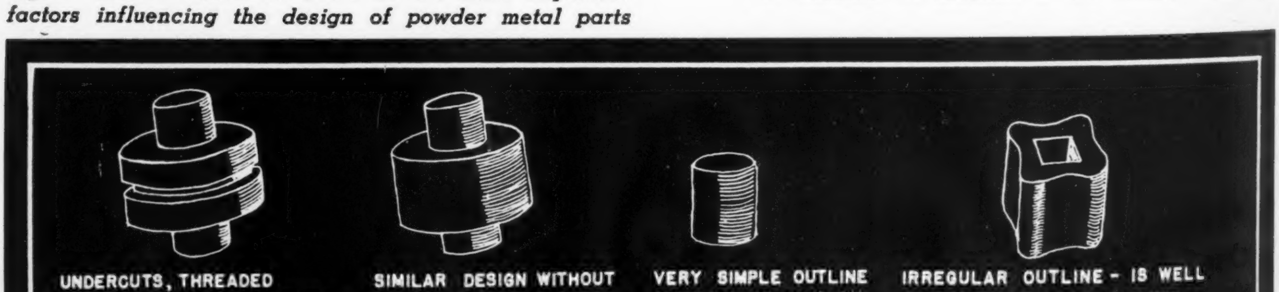


Fig. 6—Above—Similarity of structure between rolled copper (left) and sintered copper (right) is apparent from these microphotographs

Fig. 7—Below—Illustrates some of the more important factors influencing the design of powder metal parts



Another aspect which should be emphasized is the relationship between shapes and materials that can be made by powder metallurgy, and their cost. For example, a certain part that can easily be made by powder metallurgy contains a machined groove which is relatively simple to cut in a gang set-up. The same groove could also be included in the part as molded from metal powder and in many cases this procedure would be preferred. However, it may happen that the additional cost of the powder metal blank with the groove is greater than the cost of the turning operation, due to one or more of the following factors:

1. More intricate die design and die work
2. Greater allowance for setting-up time
3. Slower operation
4. More frequent breakdowns of set-up due to breakage or wear of the die parts involved
5. More careful supervision
6. More thorough inspection.

Thus certain shapes which can readily be made by powder metallurgy technique are not economically feasible if the part can also be readily made by some other method. In other cases, depending upon general shape of the part, material and tolerances, it may easily be possible to incorporate special features without additional cost.

The following general rules for the detail design of molded parts may be helpful in determining whether powder metallurgy should be considered as a possibility for a particular part:

1. Re-entrant angles in the direction of pressing cannot be molded.
2. Holes at right angles to the central axis of pressing cannot be molded.
3. Threads cannot be molded.
4. Parts more than three or four inches in length are prone to weakness of structure in the center, because the

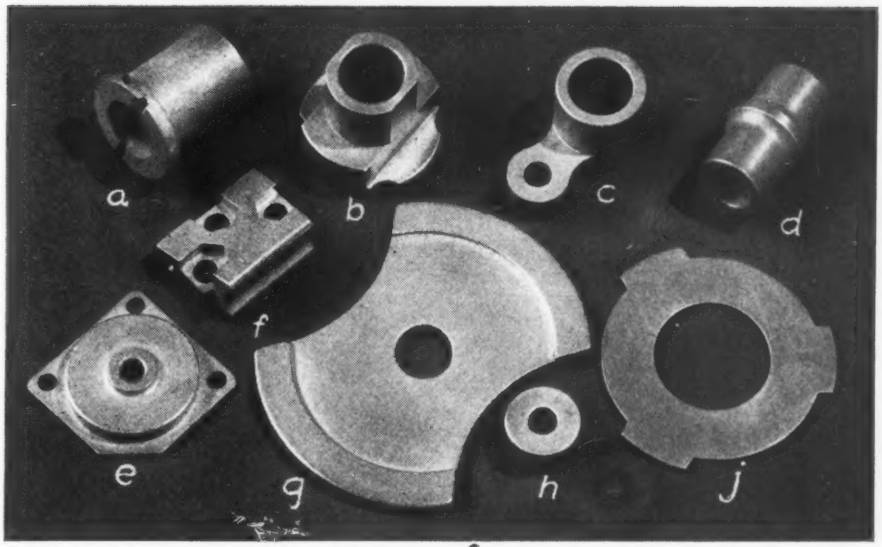
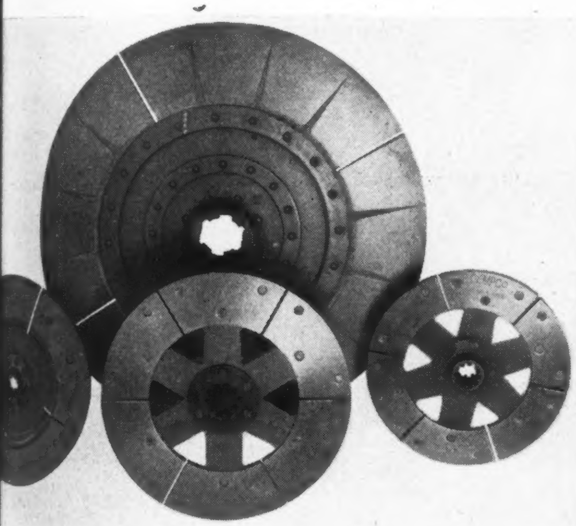


Fig. 8—Right—These powder metal parts illustrate the diversity of shapes which can be made by powder metallurgy technique

Fig. 9—Below—Clutch assemblies for automotive applications employ powdered metal facings on steel backing



pressing is done from the top and bottom only. Longer lengths may be extruded.

5. Parts that require dies of weak construction such as feather edges, small pins, narrow and deep splines, etc., should be avoided. Powder metal parts are molded at pressures of 20,000 to 80,000 pounds per square inch or even higher, and failures in the dies will occur under these pressures.
6. Bevels and radii should be allowed at all edges and angles in order to prevent flash marks.
7. It must be possible to construct dies so that, on filling, all powder is placed in final position, inasmuch as the powdered metal will not flow laterally in the die.
8. Large and sudden changes in cross-sectional area should be avoided.

Some of the foregoing rules, as well as additional pointers on design, are illustrated in *Fig.* 7.

Applications of powder metal parts may be classified as: Refractory (high melting point) metals; porous metal bearings; cemented carbides; machine parts competing with castings and other methods of fabrication; friction linings; and filters.

Of these, the first was used by the ancients who, prior to the development of smelting, were unable to obtain sufficiently high temperatures to melt iron. In modern times it is used for the manufacture of tungsten filaments for light bulbs, the melting point of tungsten (6150 degrees Fahr.) making other methods impractical.

Porous metal bearings with porosities ranging from 25 to 35 percent and impregnated with oil have long been familiar to engineers. War machines such as tanks and airplanes have been prolific users of such bearings because they need little attention. Freedom from the necessity of frequent oiling and greasing results in substantial savings in time and maintenance personnel, with corresponding increase in fighting efficiency.

Sizing operations on porous bearing bushings produce accuracies of $\pm$ .0005-inch for bore and outside diameter, closer limits if necessary, without machining. The resulting smooth finish, free of tool marks, obviates the necessity of "running-in" such bearings. In applying porous or "oil-less" bearings it is customary to base design on the "*PV*" factor (bearing pressure in pounds per square inch of projected area times surface speed in feet per minute), a value of 50,000 being considered a good average. In a particular case, materials and operating conditions will govern the selection of *PV* value, while there are limits to the pressure at low speeds and to the speed at low loads. Bronze is much used, although powder iron bearings containing from 3 to 13 per cent copper provide greater tensile strength as well as conserving substantial amounts of copper. They are extensively used in aircraft and ordnance equipment. Porous bearings are produced in sizes ranging from bores of a few thousandths of an inch to parts weighing more than sixty pounds.

Pictured in *Fig.* 8 is a variety of powder metal parts which illustrate some typical applications. Shown at *a* is a vacuum sweeper bearing made of porous iron impregnated with a plastic petroleum, for operating at 9000 revolutions per minute and required to function 2000 hours without additional lubricant. Part *b* is a slide block used on a machine-gun base, which transmits much of the shock of firing the gun. Formerly hand-made and hand-fitted, the part is now made by powder metallurgy and held so uniform in size that hand-fitting has been eliminated. The wheel bearing (*d*) is used on an industrial truck and provides self-lubrication throughout the life of the unit. The flange in the middle is difficult to mold, but

(*Concluded on Page* 180)

Fig. 1—Spiral brusholder spring for motor

Calculatin

By A. M. Wahl
Westinghouse Research Laboratories

FLAT spiral springs, consisting essentially of flat strip wound to form a spiral, have many advantages from the standpoint of energy storage within a limited space, particularly if the spring is required to deliver torque. In addition, such springs are relatively simple to manufacture. Because of these advantages, spiral springs are widely used in clocks, watches, electrical instruments and similar devices. Other applications include brush-holder springs, *Fig.* 1, phonograph motors, etc. An unusual use of this type of spring as an energy storing device is shown in the experimental circuit-breaker mechanism of *Fig.* 4.

If the spiral spring is so wound that individual turns do not come in contact, the analysis for the spring may be carried out with considerable accuracy. Such an example is provided by the hairspring of a watch. On the other hand, if the turns of the spring are wound tightly together, as is true of a phonograph motor spring, a different sort of analysis must be made because of friction between turns. These cases will therefore be treated separately, the primary purpose of the present article being a discussion of the fundamentals underlying spiral spring calculations.

In the first analysis it will be assumed that the outer end of the spring is clamped as indicated in *Fig.* 2. It also will be assumed that the spring has a large number of turns which are, however, separated sufficiently so that adjacent turns do not come in contact during deflection (1)[*] The inner end of the spring is fastened to an arbor which pivots about point O and is acted on by a torque M_o.

For a built-in condition, at the outer end A of the spring a tangential force P, a radial force R (passing through O) and a moment M_1, will act. The external torque M_o is

$$M_o = Pr + M_1 \qquad (1)$$

If M is the bending moment at any point of the spiral having the coordinates x and y, then from the statical conditions of equilibrium,

$$M = P(r+y) + M_1 - Rx \qquad (2)$$

Using the value of Pr given by Equation 1 in Equation 2

$$M = M_o\left(1+\frac{y}{r}\right) - M_1\frac{y}{r} - Rx \qquad (3)$$

The energy stored in a short length ds of the spring acted on by a moment M is from ordinary beam theory (2)

$$dU = \frac{M^2 ds}{2EI}$$

where E is the modulus of elasticity and I the moment of

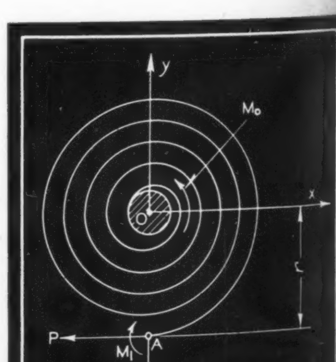


Fig. 2 — Spiral spring with large number of turns, clamped outer end

inertia of the cross section[†].

Total energy U stored in the spring is

$$U = \int_0^l dU = \int_0^l \frac{M^2 ds}{2EI} \qquad (4)$$

In this the integral is taken over the total length of the spiral.

The Castigliano theorem (2) states that the partial

*Numbers in parentheses refer to list of references at end of article.
†Where the spring is made of strip material, more accurate results will be obtained by replacing E by $E/(1-\mu^2)$ *where* μ = Poisson's ratio.

Spiral Springs

derivative of the stored energy U with respect to a statically indeterminate force or moment which does no work, must be zero. Since neither the force R nor the moment M_1 do work as the spring deflects, this means that

$$\frac{\partial U}{\partial R}=0; \quad \frac{\partial U}{\partial M_1}=0$$

Using Equation 4 and differentiating under the integral sign, these conditions give

$$\int_0^l \frac{M}{EI}\,\frac{\partial M}{\partial R}ds=0 \quad \ldots\ldots (5)$$

$$\int_0^l \frac{M}{EI}\,\frac{\partial M}{\partial M_1}ds=0 \quad \ldots\ldots (6)$$

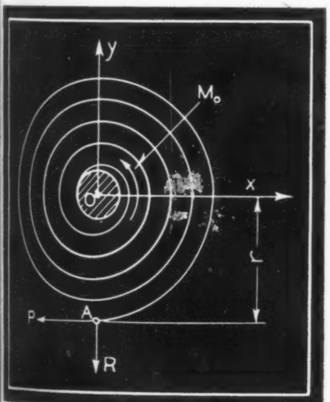


Fig. 3 — Pinned outer end of a spiral spring, large number of turns

In these l is the total length of the spiral.

Since EI is assumed constant from these equations the following conditions hold:

$$\int_0^l M\frac{\partial M}{\partial R}ds=0 \quad \ldots\ldots (7)$$

$$\int_0^l M\frac{\partial M}{\partial M_1}ds=0 \quad \ldots\ldots (8)$$

From Equation 3

$$\frac{\partial M}{\partial M_1}=-\frac{y}{r}\;;\quad \frac{\partial M}{\partial R}=-x$$

Using these equations together with Equation 3 in Equation 8,

$$\int_0^l\left[M_o\left(1+\frac{y}{r}\right)-M_1\frac{y}{r}-Rx\right]\frac{yds}{r}=0 \quad \ldots\ldots (9)$$

Similarly, using Equations 3 and 7,

$$\int_0^l\left[M_o\left(1+\frac{y}{r}\right)-M_1\frac{y}{r}-Rx\right]xds=0. \quad (10)$$

The Castigliano theorem (2) also states that the partial derivative of the stored energy U with respect to an external moment gives the angular deflection due to this moment. Thus the angular deflection ϕ due to the moment M_o becomes (using Equation 4)

$$\phi=\frac{\partial U}{\partial M_o}=\int_0^l \frac{M}{EI}\,\frac{\partial M}{\partial M_o}ds \quad \ldots\ldots (11)$$

Differentiating Equation 3,

$$\frac{\partial M}{\partial M_o}=1+\frac{y}{r} \quad \ldots\ldots (12)$$

Using Equations 3 and 12 in 11 the angular deflection ϕ becomes

$$\phi=\frac{1}{EI}\int_0^l\left[M_o\left(1+\frac{y}{r}\right)-M_1\frac{y}{r}-Rx\right]\left(1+\frac{y}{r}\right)ds=0 \quad \ldots\ldots (13)$$

Equation 10 may be written

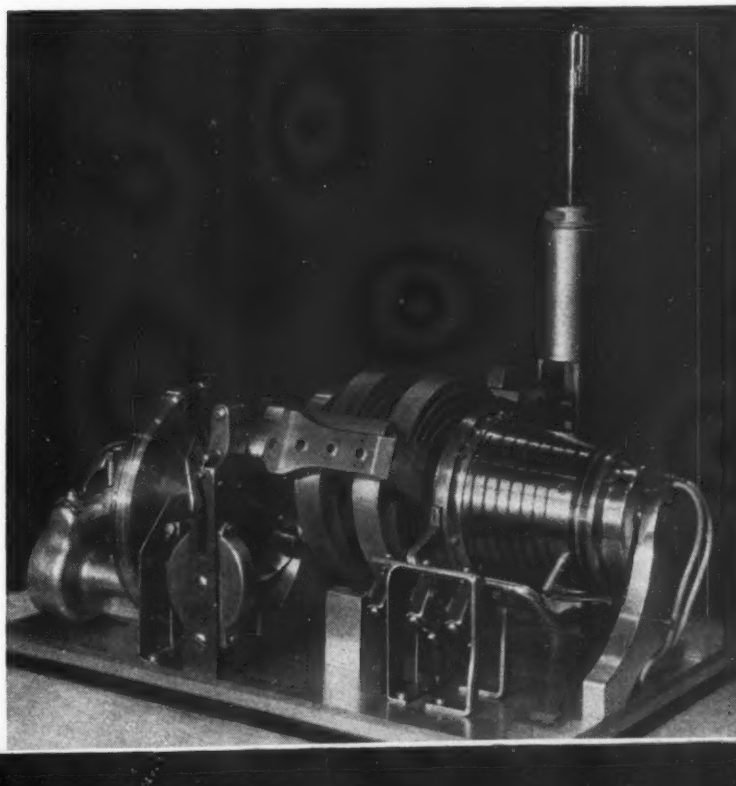
$$\int_0^l M_o xds+\int_0^l M_o\frac{xy}{r}ds-\int_0^l M_1\frac{xy}{r}ds-\int_0^l Rx^2ds=0. \quad (14)$$

For a spiral spring with a large number of turns, the following equations also hold with sufficient exactitude for practical purposes:

$$\int_0^l xds=0\;;\quad \int_0^l yds=0\;;\quad \int_0^l xyds=0$$

This means that the first three integrals of Equation 14

Fig. 4—Experimental mechanism utilizes spiral springs



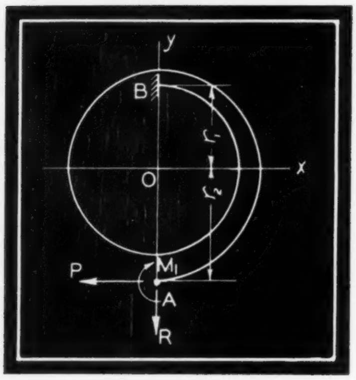


Fig. 5 — Spiral spring with small number of turns

are zero. Hence

$$\int_0^l Rx^2 ds = 0$$

Since $\int x^2 ds$ cannot be zero it follows from this equation that $R=0$. In other words, at the outer end A of such a spring, *Fig.* 2, the radial load R will be zero. For a small number of turns, this will not be true, however.

From Equation 9

$$\int_0^l M_o \frac{y}{r} ds + \int_0^l M_o \frac{y^2}{r^2} ds - \int_0^l M_1 \frac{y^2}{r^2} ds - \int_0^l R \frac{xy}{r} ds = 0$$

Since $R=0$ and $\int (xy/r)ds=0$ for a large number of turns, this equation reduces to

$$\int_0^l (M_o - M_1) \frac{y^2}{r^2} ds = 0 \quad \text{(15)}$$

Since $\int (y^2/r^2)ds$ cannot be zero, Equation 15 shows that $M_o - M_1 = 0$ or $M_o = M_1$. Using this condition in Equation 1, $P=0$ which means that the tangential force at the end A, *Fig.* 2, also vanishes for the condition assumed. Since R is also zero, and $M_1 = M_o$, Equation 3 shows that $M = M_o$ which means that the moment is constant along the length of the spring.

Taking $M_1 = M_o$ and $R=0$, Equation 13 reduces to

$$\phi = \frac{1}{EI}\left[\int_0^l M_o ds + \int_0^l M_o \frac{y}{r} ds\right] \quad \text{(16)}$$

Again for a large number of turns $\int (y/r)ds=0$ and $\int ds = l$.

Hence the angular deflection ϕ becomes

$$\phi = \frac{M_o l}{EI} \quad \text{(17)}$$

In this ϕ is given in radians (or degrees divided by 57.3). This equation thus states that the angular deflection of a spiral spring with a large number of turns and a length l with built-in outer end is the same as that of a straight beam of length l built in at one end and loaded by a moment at the other.

Since the moment is constant along the length of the spiral the nominal stress σ (neglecting curvature effects) for the case of *Fig.* 2 will be given by

$$\sigma = \frac{6M_o}{bh^2} \quad \text{(18)}$$

where b=width of spring cross section and h=thickness of strip.

Usually there is some stress concentration at the clamped ends of the spring. If fatigue or repeated loading is present (as in the hairspring of a watch), this should be taken into account by multiplying the stress calculated from Equation 18 by a stress concentration factor§. For most applications where the number of repetitions of load during the life of the spring is small, stress concentration effects are neglected, however.

Where a small number of turns is involved, Equations 17 and 18 should be modified as discussed later.

When Outer End Is Pinned

Frequently in practice, for manufacturing reasons the outer end of a spiral spring may be held with a pin instead of being clamped. Neglecting friction no moment will act at the pinned end A and the loading conditions

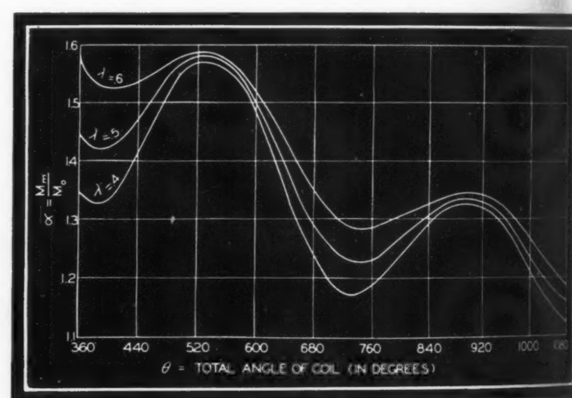
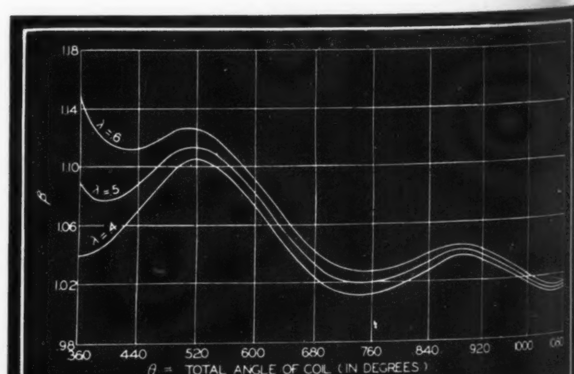


Fig. 6—Stress concentration factor α for spiral spring with small number of turns

Fig. 7—Below—Stiffness factor for spiral spring with small number of turns



will be those shown in *Fig.* 3. In this case the external moment M_o will be

$$M_o = Pr \quad \text{(19)}$$

Assuming that the coils do not touch each other, the

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§See writer's article, MACHINE DESIGN, May, 1940, for a further discussion of stress concentration effects.

moment at any point of the spiral having the coordinates x and y becomes

$$M=P(r+y)-Rx \qquad (20)$$

Using Equation 19, this expression may be written

$$M=M_o\left(1+\frac{y}{r}\right)-Rx \qquad (21)$$

From the Castigliano theorem, as before,

$$\frac{\partial U}{\partial R}=0$$

This follows as a consequence of the fact that the radial force R does no work during deflection of the spring. Therefore Equation 5 also applies.

Differentiating Equation 20 with respect to R and sub-

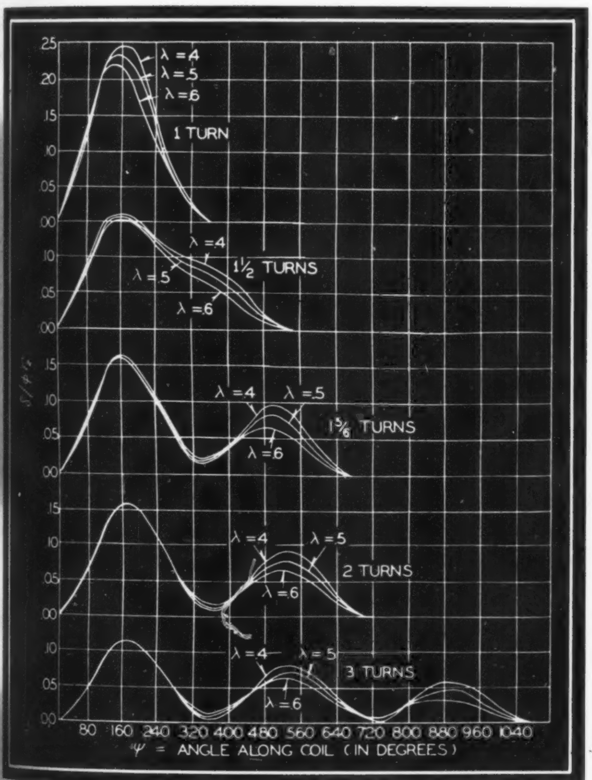


Fig. 8—Above—Curves for finding radial deflection of coils of spiral spring. Angle ψ measured from outer end

stituting in Equation 5, the following expression is obtained:

$$\int_0^l\left[Pr\left(1+\frac{y}{r}\right)-Rx\right]xds=0$$

or

$$P\int_0^l rxds+P\int_0^l xyds-R\int_0^l x^2ds=0$$

As before, for a large number of turns, the first two integrals may be taken as zero. Hence this equation gives

$$\int_0^l Rx^2ds=0 \qquad (22)$$

Since $\int x^2ds$ is different from zero this means that the radial force R is also equal to zero for the pin-ended case, *Fig.* 3.

As before the angular rotation ϕ is given by Equation 11, using the value of M given by Equation 21. Differentiating the latter partially with respect to M_o and substituting the result together with Equation 21 in Equation 11,

$$\phi=\frac{1}{EI}\int_0^l\left[M_o\left(1+\frac{y}{r}\right)-Rx\right]\left(1+\frac{y}{r}\right)ds$$

Since R was found to be zero this simplifies to

$$\phi=\frac{M_o}{EI}\int_0^l\left(1+\frac{2y}{r}+\frac{y^2}{r^2}\right)ds$$

From the condition that $\int yds=0$ for a large number of turns, this equation becomes

$$\phi=\frac{M_o}{EI}\int_0^l\left(1+\frac{y^2}{r^2}\right)ds \qquad (23)$$

Also for a large number of turns

$$\int_0^l\frac{y^2}{r^2}ds=\frac{l}{4}$$

This value is approximate. Using it in Equation 23, the expression for ϕ simplifies to

$$\phi=1.25\frac{M_ol}{EI} \qquad (24)$$

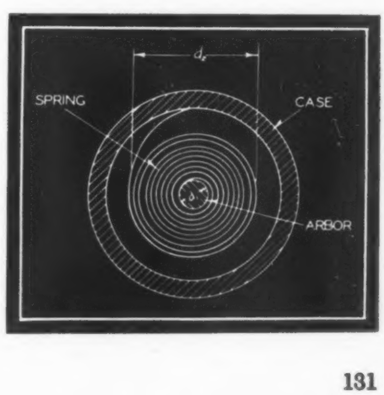
Comparing this with Equation 17 it is seen that, for the same external moment M_o, a spiral spring with a hinged outer end will have about 25 per cent more angular deflection than the corresponding one with clamped outer end, provided adjacent turns do not come in contact.

The maximum moment in the spring will occur when $y=r$ (approximately). Taking $y=r$ in Equation 21, since $R=0$, this gives a maximum value $M=2M_o$. The maximum stress is then

$$\sigma=\frac{6(2M_o)}{bh^2}=\frac{12M_o}{bh^2} \qquad (25)$$

For a given external moment M_o this stress is twice that

Fig. 9—Spiral spring wound on arbor



for a spring with a clamped outer edge (Equation 18). However, it should be noted that it occurs at a point opposite to the pinned end where there is no stress concentration. If the arbor diameter is small compared to r, the moment at the inner clamped end will be M_0 which is the same as that for a spring with clamped outer end. This means that the stress at this end will also be the same and, since there is always some stress concentration at this point, it may still happen that in some cases this is the limiting stress. Also touching of the coils, as may easily occur in practice, will tend to reduce the stress given by Equation 25. For a more extensive discussion of spiral springs with large numbers of turns the reader is referred to the article by Van den Broek (3).

Example: A steel torsion spring having a pinned end A, *Fig.* 3, is subject to an external torque M_0 equal to 25 inch-pounds. The outer diameter is 2 inches, the bar section is ½ by .06-inch, and the total length 15 inches. Required the stress and the deflection. Assuming a modulus $E=30\times10^6$ pounds per square inch,

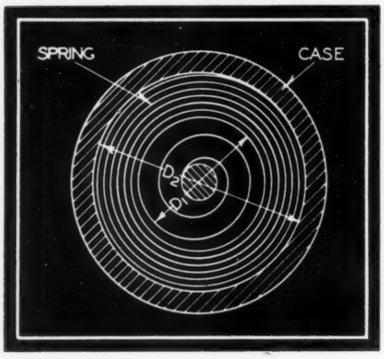


Fig. 10—Unwound spring resting against case

$$I=\frac{bh^3}{12}=\frac{.5(.06)^3}{12}=9\times10^{-6}$$

From Equation 24 for a pinned end

$$\phi=1.25\frac{M_0 l}{EI}=\frac{1.25\times25\times15}{30\times10^6\times9\times10^{-6}}=1.73 \text{ radians}$$

This corresponds to an angular rotation of $1.73(57.3)=99$ degrees.

From Equation 25 the maximum stress is

$$\sigma=\frac{12M_0}{bh^2}=\frac{12\times25}{.5(.06)^2}=167000 \text{ lb./sq. in.}$$

The stress at the clamped end O where stress concentration occurs will be but half of this or 84000 pounds per square inch. However, this latter stress will be augmented by stress concentration effects due to clamping of the end.

Springs with Few Turns

In some practical cases where large torques are involved it is necessary to use a relatively heavy cross section for the spiral spring as well as an arbor of larger diameter. This means that the number of turns in the spring may be relatively small so that the previously discussed theory (based on a large number of turns) no longer applies. However, an analysis of this case may be made by using similar methods to those described previously (4). This analysis will be briefly outlined.

Considering a spring with a small number of turns as

Inner End Is Assumed Clamped

shown in *Fig.* 5, it is assumed that the spring is clamped or built in at point B at a radius r_1 while the outer end A may move in an arc about point O. The angular deflection of the end A (in radians) is equal to the movement of A along the arc divided by the outer radius r_2.

The moment M at any point on the spiral having the coordinates x and y will be given by Equation 2 using r_2 for r. This is,

$$M=P(r_2+y)+M_1-Rx \qquad (26)$$

The three unknown quantities M_1, P and R in this equation may be determined from three equations obtained by using the Castigliano theorem. Since the point A is assumed constrained to move along a circular arc about O, the work done by the force R must be zero. This means that $\partial U/\partial R=0$ and Equation 7 holds.

By differentiating Equation 26 partially with respect to R,

$$\frac{\partial M}{\partial R}=-x$$

Using this and Equation 26 in Equation 7, the following expression is obtained:

$$-\int_0^l [P(r_2+y)x+M_1x-Rx^2]ds=0 \qquad (27)$$

During deflection of the end of the spring through an angle ϕ, the moment M_1 will also move through the same angle. From the Castigliano theorem this condition gives

$$\phi=\frac{\partial U}{\partial M_1}=\frac{1}{EI}\int_0^l M\frac{\partial M}{\partial M_1}ds \qquad (28)$$

From Equation 26, $\partial M/\partial M_1=1$. Using this in Equation 28, together with Equation 26,

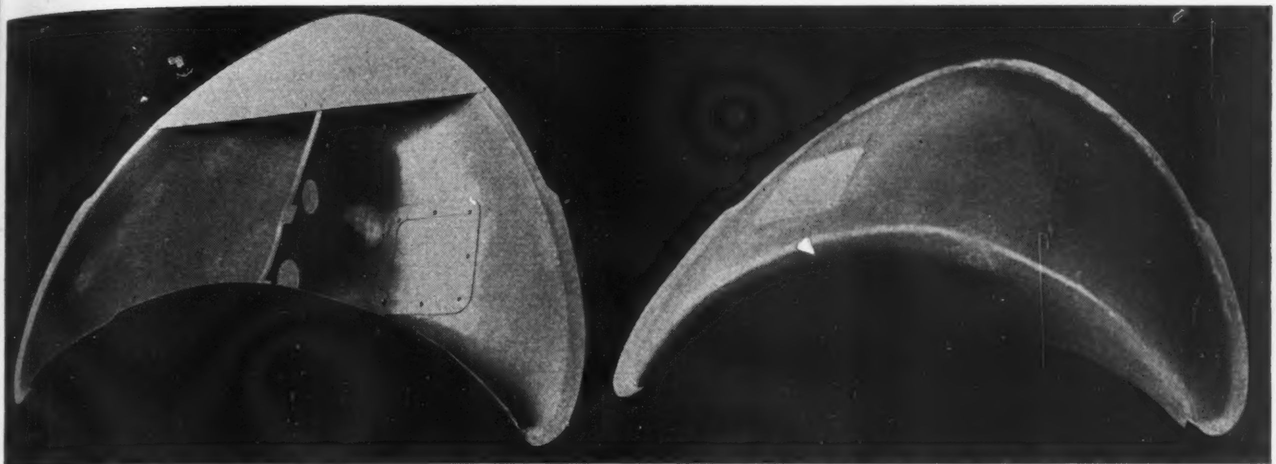
$$\phi=\frac{1}{EI}\int_0^l Mds=\frac{1}{EI}\int_0^l\left[P(r_2+y)+M_1-Rx\right]ds \qquad (29)$$

Another equation is also obtained from the Castigliano theorem which states that the total deflection in the direction of the force P must be equal to $\partial U/\partial P$. Since P is always assumed to be directed along the arc of motion of the end A, *Fig.* 5, this deflection will be $r_2\phi$. Hence

$$r_2\phi=\frac{\partial U}{\partial P}=\frac{1}{EI}\int_0^l M\frac{\partial M}{\partial P}ds \qquad (30)$$

But from Equation 26, $\partial M/\partial P=r_2+y$. Using this together with Equation 26 in Equation 30,

(*Continued on Page* 208)



—*Photo, courtesy Swedlow Aeroplastics Corp.*

Wheel fairing for aircraft is molded from fiberglas laminated plastic

"No-Pressure" Laminated Plastics

By Cecil W. Armstrong
Senior Research Engineer
Lockheed Aircraft Corp.

ENGINEERS, particularly those in the aviation industry, are vitally interested in high-strength, low-density materials which show promise of utilization in airplane structures. This interest exists because of the following reasons:

1. Need for further reduction in weight of all types of airplanes in order to obtain better performance
2. Need for increasing the rigidity of all thin gage sections to reduce local failures resulting from vibration and to maintain contours under all flight conditions
3. Need for reducing the number of manhours required for tooling, fabrication, and final assembly
4. Need for improvement in the overall smoothness of all aerodynamic surfaces.

It is generally agreed among aeronautical engineers that the development of a low-density structural plastic material, capable of being molded in large assemblies with inexpensive molds, would help to satisfy these needs. The word "structural" implies that the plastic material will possess certain minimum mechanical properties. For structural use in airplanes, the strength-weight ratios and other mechanical properties must compare favorably with those of the commonly used aluminum alloys.

Because so many new resins have recently been developed, it has become exceedingly difficult for the engineer to choose any one material for a specific application. Need exists for reliable engineering data on plastic materials so that an intelligent selection of a material for a specific application can be accomplished.

Among the new resins which have become commercially available (military requirements first, of course), there are several thermohardening resins which are unique in that no external pressure is required during the process of molding a plastic part. These new resins may be used in combination with high-strength filler materials to produce low-density, high-strength laminated plastics which soon may fill some of the needs already enumerated.

To produce a laminated plastic article from one of these "no pressure" resins, one or more layers of the filler material may be wrapped around or draped over a mold, the filler material being saturated with the liquid resin either before or after placing in contact with the mold. The laminate then is cured (hardened) by application of heat. Curing temperatures seldom exceed 240 degrees Fahr. The curing period may require from thirty minutes to eight hours, depending upon the particular resin, the thickness of the laminate, and the heat conductivity of the mold. If a smooth, glossy surface is desired, nonporous cover sheets such as Cellophane may be used.

Forming Intricate Shapes

Parts having intricate shapes and double contours may necessitate the use of some pressure (.1 to 10 pounds per square inch) to keep the impregnated fabric filler material in intimate contact with all surfaces of the mold and to prevent free resin from accumulating in localized spots. For application of these pressures, the use of thin transparent films of inexpensive thermoplastic materials has been found to be more suitable than the use of expensive synthetic rubber bags. Many novel and ingenious techniques already have been developed for the fabrication of complete assemblies, which if made of metal would require the forming and assembly of several contoured parts. Because of the fact that pressures are low, molds may be simple, light in weight, and inexpensive. Primary requirement of molds for fabrication of parts from these new resins is that they be to correct dimensions and contours.

A preliminary study of the limited amount of available

*Abstract of a paper presented at the recent semiannual meeting of the American Society of Mechanical Engineers.

Table I
Physical Test Results

LAMINATE DESIGNATION	223	224	309	236	221	241
FILLER, FIBERGLAS NO.	OC-63	OC-63	OC-63	ECC-11-127	ECC-11-148	ECC-11-161
NUMBER OF LAMINAE	12	12	8	18	10	8
STACK ARRANGEMENT	PARALLEL	CROSSED 90°	CROSSED 90°	CROSSED 90°	PARALLEL	CROSSED 90°
NOMINAL THICKNESS, INCHES	.104	.107	.107	.128	.124	.121
SPECIFIC GRAVITY	1.96	1.93	1.69	1.81	1.80	1.79
TENSION						
DIRECTION OF LOAD	WITH WARP	—	—	—	WITH FILL	—
ULTIMATE LOAD, LBS.	6,390	3,140	2,095	2,840	2,070	2,210
SPECIMEN WIDTH, IN.	604	.502	.502	502	.482	.505
ULT. LOAD PER INCH OF WIDTH PER LAMINA	880	520	520	315	430	550
TANGENT PROPORTIONAL LIMIT P.S.I.	50,000	32,000	21,000	26,000	13,000	13,500
.01% OFFSET PROPORTIONAL LIMIT	58,000	41,000	25,000	27,500	15,000	15,500
.2% OFFSET YIELD STRESS	—	58,000	—	38,700	30,800	24,300
ULTIMATE TENSILE STRESS	105,000	58,500	39,000	44,200	34,600	36,200
YOUNG'S MODULUS OF ELASTICITY P.S.I.	5,960,000	2,800,000	1,900,000	2,100,000	1,500,000	1,900,000
ELONGATION AT FAILURE (% OVER 2 INCH LENGTH)	1.8	2.3	2.1	2.6	2.6	2.9
COMPRESSION (EDGEWISE)						
DIRECTION OF LOAD	WITH WARP	—	—	—	WITH FILL	—
ULTIMATE LOAD, LBS.	1,340	1,380	1,580	1,393	1,000	1,200
SPECIMEN WIDTH, IN.	.496	500	.495	.500	.500	.500
ULT. LOAD PER INCH OF WIDTH PER LAMINA	225	230	400	155	200	300
TANGENT PROPORTIONAL LIMIT P.S.I.	26,100	25,950	21,500	14,000	11,000	10,000
.01% OFFSET PROPORTIONAL LIMIT	—	—	23,700	15,000	14,000	12,000
ULTIMATE COMPRESSIVE STRESS	26,100	26,000	29,000	22,500	16,900	19,600
YOUNG'S MODULUS OF ELASTICITY P.S.I.	5,500,000	3,000,000	2,260,000	2,800,000	2,200,000	2,300,000
DEFORMATION (% OVER 2 INCH LENGTH)	.47	.86	1.38	.86	.75	.93
MANNER OF FAILURE	DIAGONAL SHEAR	DIAGONAL SHEAR	DIAGONAL SHEAR	DIAGONAL SHEAR	DIAGONAL SHEAR	DIAGONAL SHEAR
BENDING (FLATWISE)						
LENGTH, WIDTH, THICKNESS, INCHES	5x1.02x.102	5x.745x.106	5x.749x.109	5x.751x.128	5x.751x.126	5x.746x.116
SPAN, INCHES	3	3	3	3	3	3
ULTIMATE LOAD AT CENTER OF SPAN, LBS.	138	90	128	105	94	78
TANGENT PROPORTIONAL LIMIT P.S.I.	55,000	41,000	45,000	17,000	19,000	19,000
MODULUS OF RUPTURE, P.S.I.	59,300	48,200	64,800	38,400	35,500	34,900
MODULUS OF ELASTICITY, P.S.I.	5,950,000	3,000,000	2,100,000	2,300,000	1,630,000	2,080,000
BEARING						
HOLE DIAMETER	—	.124	.124	.124	.124	.124
NOMINAL BEARING STRENGTH (4% HOLE DEFORMATION)	—	28,000	23,500	20,000	29,500	23,300
ULTIMATE BEARING STRENGTH, P.S.I.	—	32,100	31,300	38,500	34,800	34,600

Table II
Specific Strength Comparison

MATERIAL	① SPECIFIC TENSILE STRENGTH P.S.I.	② SPECIFIC TENSILE MODULUS P.S.I.	③ SPECIFIC BUCKLING STABILITY P.S.I.	④ SPECIFIC MODULUS OF RUPTURE P.S.I.	⑤ SPECIFIC ULT. BEARING STRENGTH P.S.I.
MR-1A FIBERGLAS-223	53,500	3,040,000	790,000	15,400	—
MR-1A FIBERGLAS-224	30,300	1,450,000	416,000	12,900	16,600
MR-1A FIBERGLAS-309	23,000	1,120,000	435,000	22,600	18,500
MR-1A FIBERGLAS-236	24,400	1,160,000	388,000	11,700	21,300
MR-1A FIBERGLAS-221	19,200	833,000	280,000	10,900	19,300
MR-1A FIBERGLAS-241	20,200	1,060,000	362,000	10,900	19,300
24S-T ALCLAD ALUMINUM ALLOY	20,200	3,800,000	495,000	7,300	29,600
24S-RT ALCLAD ALUMINUM ALLOY	22,400	3,800,000	495,000	8,100	32,400

① Specific Tensile Strength = Ult. tensile strength divided by specific gravity
② Specific Tensile Modulus = Tension modulus divided by specific gravity
③ Specific Buckling Stability = Flexural modulus divided by (specific gravity)^3
④ Specific Modulus of Rupture = Modulus of rupture divided by (specific gravity)^2
⑤ Specific Ult. Bearing Strength = Ult. bearing strength divided by specific gravity

data, supplemented by various laboratory tests, indicated that the MR-1A resin (an allyl derivative), when laminated with certain of the fiberglas fabrics, possessed better mechanical properties than any of the commercially available "no pressure" resins. Accordingly, a modest test program was undertaken by the Lockheed Structures Research Laboratory, results of which are here reported.

Typical test results are given in Table I. Certain of these values, adjusted to an equivalent weight base, are compared with corresponding values for two aluminum alloys in Table II. Attention is directed to the fact that these laminates are anisotropic, resulting from parallel stacking or cross stacking (alternate laminae oriented at right angles) of unidirectional materials. Results shown in Table I were obtained from specimens cut parallel to one of the two principal directions of the laminates. Preliminary tensile tests made from specimens cut at forty-five degrees with the principal directions of the cross-stacked laminates exhibited ultimate tensile strength and tensile modulus values thirty to forty per cent lower than corresponding "with grain" values.

Attention is directed to the fact that both the thickness and density of the laminate are dependent upon the relative proportion of resin and filler materials. In tension, most of the load is carried by the filler material. Two laminates, each containing the same number of laminae but varying in resin content, might carry equal tensile loads, but because of the greater thickness would have different ultimate unit stress and modulus values. Examination of the data will show that the resin content (low resin content results in high specific gravity values) for optimum tensile properties will not result in optimum bend and compression properties. This fact may be demonstrated by comparing data obtained on laminate 224 with corresponding data obtained on laminate 309.

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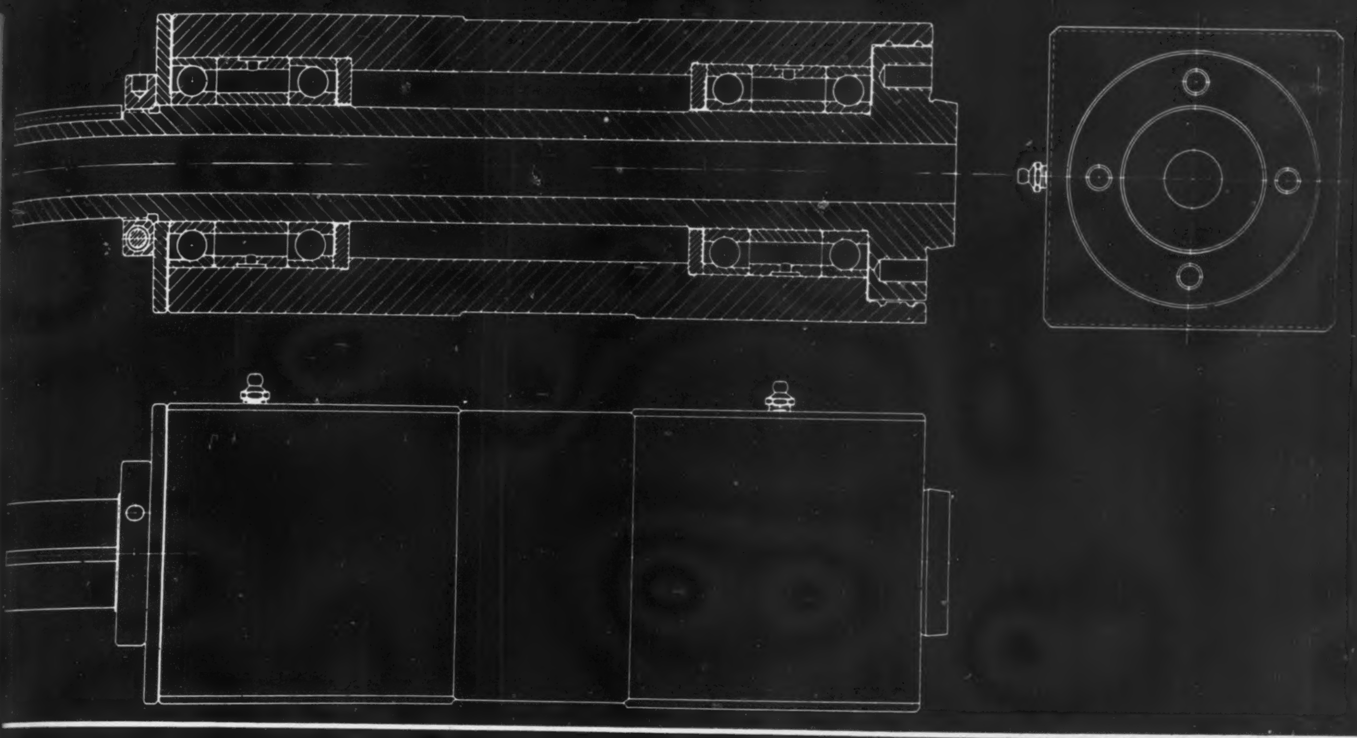

—*Drawings, courtesy Gisholt Machine Co.*

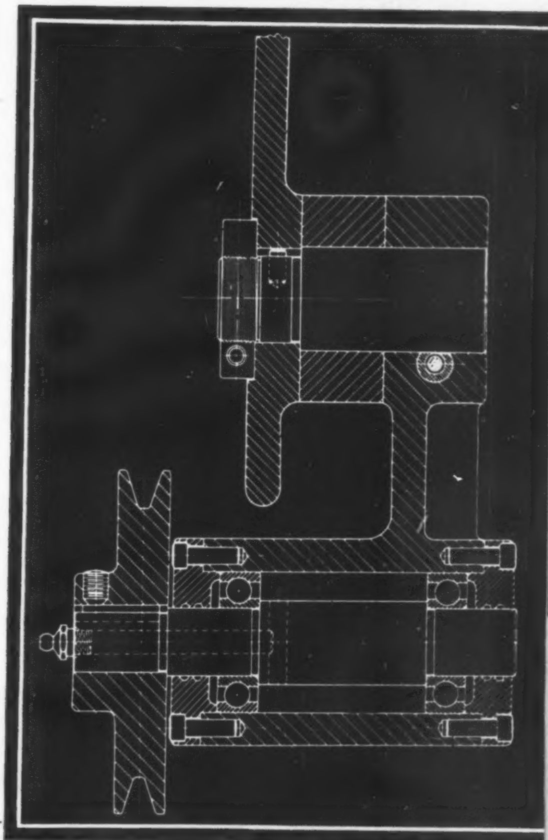

Fig. 31—Top—Headstock is based on golden complement rectangle and summation series, retaining design features

Fig. 32—Above—Unity in design is achieved for idler pulley by applying the same principles as in Fig. 31

Applying Principles of Dynamic Symmetry

Sequel to series of articles in the past three issues under the title "The Shape of Things To Come"

By R. S. Elberty
Consulting Engineer

ART IS a controversial subject and there are artists who refuse to accept dynamic symmetry arguing that art must not be bound by rules. In like manner, machine designers have objected to the use of dynamic symmetry on the ground that they do not care to be restricted, and that dynamic symmetry is not functional. The practical engineer will reject appearance features that add to the cost of the machine, and he will favor functional design in cases of conflict between functional and symmetrical features. However, any design offers many

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Emphasizing the usefulness of the theory of dynamic symmetry, this contribution shows how the principles discussed in the preceding articles may be applied effectively in obtaining an integrated and correct design

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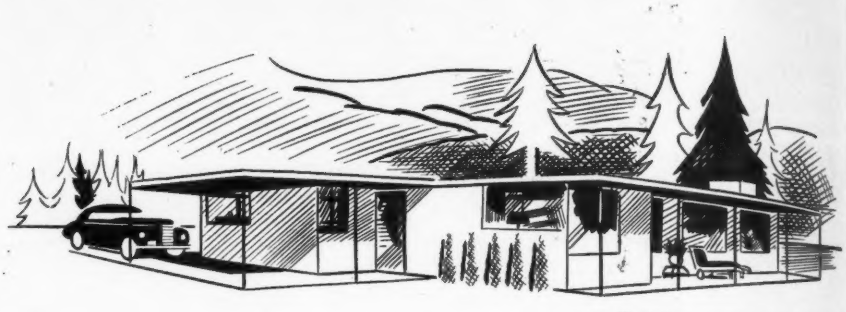


Fig. 33—Typical of the application of the principles is this design of a prefabricated house in which all parts bear a definite relationship to each other and therefore to the whole

—Drawing, courtesy John Moodie

cases where the designer must use judgment in the proportioning of machine parts, cases where functional considerations are of small importance. Dynamic symmetry is a practical tool for the correct solution of this type of design problem.

Headstock and Idler Harmonize

For example, the machine tool headstock, *Fig.* 31, shows a ball bearing mounted spindle using the American Standard 4" *A*-2 lathe spindle nose and tandem mounted No. 210 precision ball bearings. The spindle has been designed for a minimum overhang and a rigid bearing mounting. Its design is functional and uses certain standardized parts, no functional features having been conceded in the interests of symmetry. A GC (golden complement) rectangle has been selected as the basis for the outward appearance of this spindle. The summation series* has been used, the units being selected in inches. Thus, the spindle housing is 50 inches square by 13 inches long. Finished mounting pads are 5 inches long, the center relieved portion being 3 inches long. The entire composition is a GC rectangle composed of two squares and one 1/GR, or a recriprocal golden rectangle. The external appearance is pleasing from any viewpoint; there is no conflict between functional and symmetrical requirements.

Idler pulleys to maintain belt tension on the headstock or to drive auxiliary equipment utilize No. 205 ball bearings for carrying the load at the speeds required, the bearings being spaced effectively far apart. Symmetrical considerations were met by making the bearing housing assembly 3 inches in diameter and 5 inches long. Sufficient belt take-up is obtained with a 5-inch center-to-center length of arm, and the clamping hub is made 3 inches in diameter to match the bearing housing. *Fig.* 32 shows the results obtained from this design and a comparison of *Figs.* 31 and 32 indicates how the application of dynamic symmetry has achieved a unity of design between these parts that are so different in appearance. Several functional considerations on *Fig.* 32 are dictated by the dimensions of A-section V-belts. The pulley can be reversed, and the washer omitted from the stud, allowing the idler pulley to engage V-belts in any one of four planes depending on the assembly of the parts. Since these functional considerations show some conflict with the symmetry of the summation series, symmetry has been omitted except that the idler pulley has been made 5 inches in diameter.

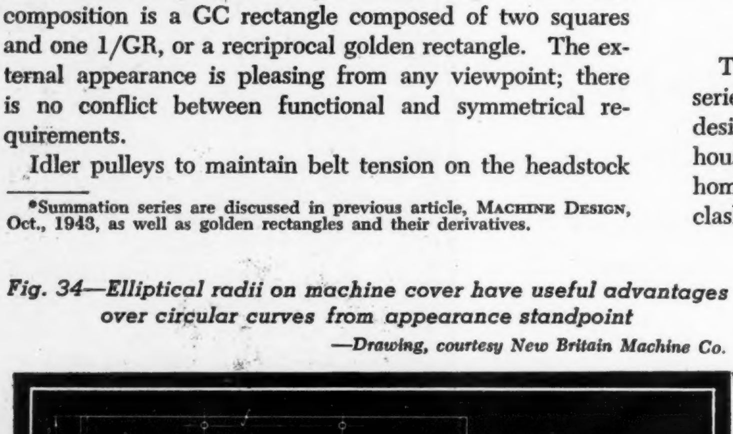
Series Could Apply To Related Machines

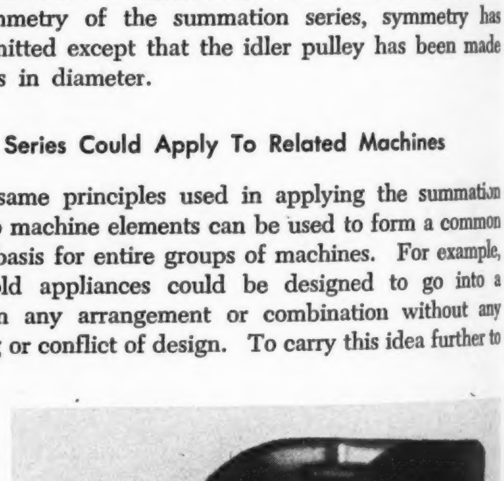
The same principles used in applying the summation series to machine elements can be used to form a common design basis for entire groups of machines. For example, household appliances could be designed to go into a home in any arrangement or combination without any clashing or conflict of design. To carry this idea further to

*Summation series are discussed in previous article, MACHINE DESIGN, Oct., 1943, as well as golden rectangles and their derivatives.

Fig. 34—Elliptical radii on machine cover have useful advantages over circular curves from appearance standpoint

—Drawing, courtesy New Britain Machine Co.





—Photo, courtesy New Britain Machine Co.

Fig. 35—Cover in Fig. 34 shows how elliptical curves integrate appearance

embody the factory-built home, the selection of such a system now will enable our homes of the future to be assembled in a variety of ways and to be correctly styled. *Fig.* 33 shows the design of a small house based on the summation series. The appearance would be equally pleasing with several optional groupings of the rooms, because each room bears a definite relationship to the others and therefore to any assembly of units.

With cast iron construction, generous corner radii and fillets are correct from the viewpoint of foundry practice. These features add strength to castings and make the machines easy to clean and paint. Designers tend to use

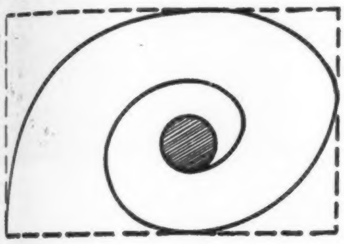


Fig. 36 — Scroll employing quadrants of circles and ellipses

circular fillets due to ease in drafting, and the pattern makers probably favor this construction because it makes their work easier. But once the pattern is made the cost of casting is the same, and thousands of castings have been ugly only because a circle is easy to draw. The circle, based on a square, is static in nature; dynamic radii may be based on ellipses. Thus, it is possible to have corner radii in root 2, root 3, etc., construction. *Fig.* 34 shows a machine cover designed with elliptical radii. Fig. 35 shows this cover and the associated machine parts. The elliptical radii achieve unity in the design.

The GR has been shown (*Fig.* 24†) to be composed of a series of squares, and circular radii can be used in the dynamic sense on GR, GC, root 5 and root 4 rectangles. Fig. 36 shows a scroll composed of quadrants of alter-

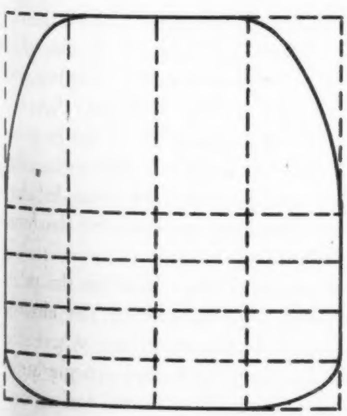


Fig. 37 — Square divided into root 4 and root 1/4 rectangles to aid in achieving pleasing elliptical radii

nate circles and ellipses based on the GR. *Fig.* 37 shows a division of a square into two root 4 rectangles and eight root ¼ rectangles all through the use of elliptical quadrants based on the root 4 proportion.

These are simple examples of the application of geometrical curves; many other applications will occur to the machine designer. Curved surfaces might well use other geometrical curves—for example, the parabola and hyperbola which are curves closely related to the ellipse.

†Machine Design, Oct., 1943, Page 92.

Since dynamic symmetry is based on higher mathematics, there is no reason why solid and analytical geometry should not be utilized to enrich designs. Streamlining is a product of our modern life both geometrical and functional in its nature and is therefore a further development of dynamic symmetry—the development of the geometry of speed.

The motor, hydraulic pump and tank combination shown in *Fig.* 38 utilizes a synthetic summation series as a design basis. The motor frame is standard with the manufacturer, and 3¾ inches long by 6¼ inches in diameter. The summation series was selected to include these numbers, the entire series being 1¼, 2½, 3¾, 6¼, 10 and 16¼. Any dimension is therefore related to all the other dimensions, and the design utilizes root 4, GR and GC proportions as accurately as the series will permit.

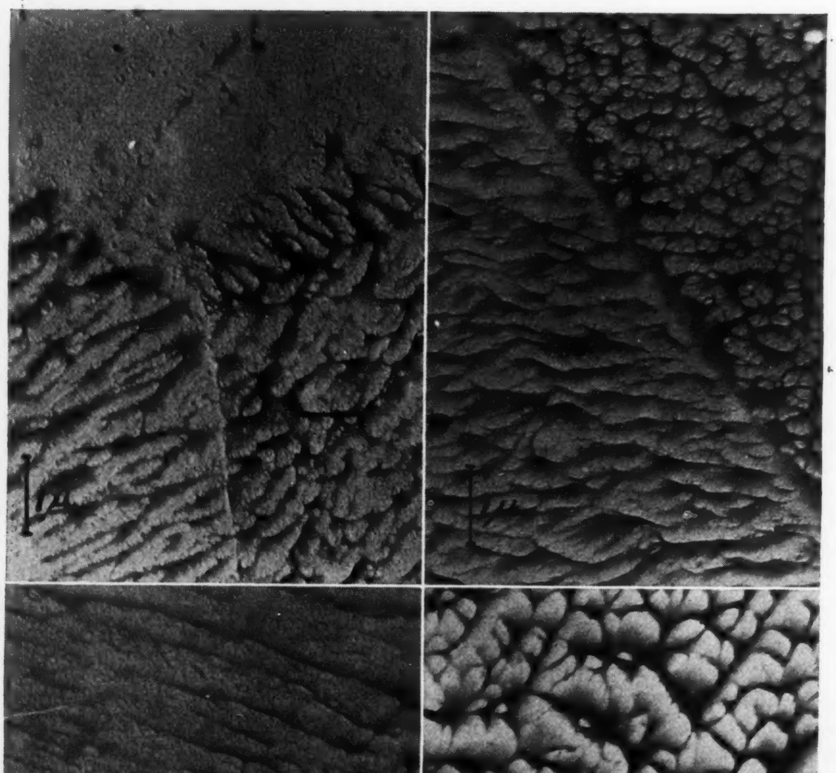
Fig. 38—Pump designed for postwar market required only minor changes to embody summation series

The actual functional requirements of this pump do not concern this discussion. However, the entire design was first based on requirements and later styled. Many dimensions were unchanged; the greatest change in dimension from the original design was ⅜ inches. This pump is a post-war development and publication of its operating features is not permissible at the present writing.

Engineers understand and work in the field of mathematics. The application of mathematics to design appearance should be a step easily taken by machine designers. The problem of making an artist out of an engineer is certainly no greater than that of making an engineer out of an artist. Dynamic symmetry bridges the gap and provides the machine designer with design fundamentals closely related to engineering through the medium of mathematics.

Seeing Metals at High Magnification*

By Charles S. Barrett
Carnegie Institute of Technology



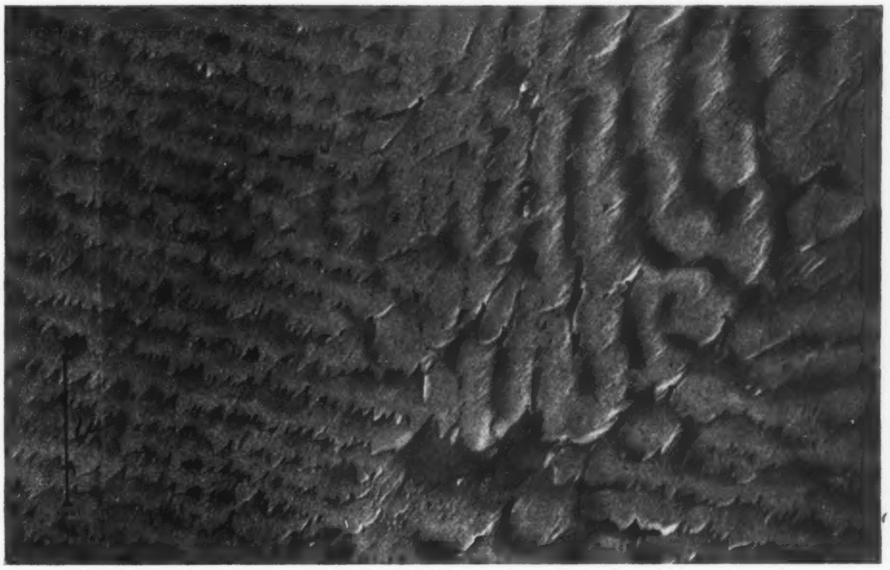
High-purity copper, magnification 10,000, after annealing one hour at a temperature of 800 degrees Cent.

RESOLVING power of a light microscope, which is limited by the wave length of the light used and the numerical aperture of the objective lens, seldom exceeds about .5 microns (5000 Angstroms). The electron microscope, using a wave length only 1/100,000 that of ordinary light, and an electron lens having a numerical aperture of about .02 instead of the usual 1.2 to 1.4, should have a theoretical resolving power some 1500 times better. The best obtained thus far, however, is 40 Angstroms, which is 100 times better than the optical microscope. Resolution in metallographic applications is limited by the details that can be developed by etching and transferred to a replica, and the present results indicate that two spots 150 Angstroms† apart can be definitely resolved by the polystyrene-silica method, and roughly the same distances (perhaps slightly greater) by the formvar method.

Shadows and dark lines on the prints correspond to shadows in the electron pattern, and these occur where the replica appears thick and opaque to the electron beam. If a metal surface contains narrow grooves after etching, polystyrene will be pressed into the grooves and form projecting fins. It appears that silica is deposited uniformly over the surfaces of the flat places and on the sides of these polystyrene fins; all flat areas perpendicular to the electron beam

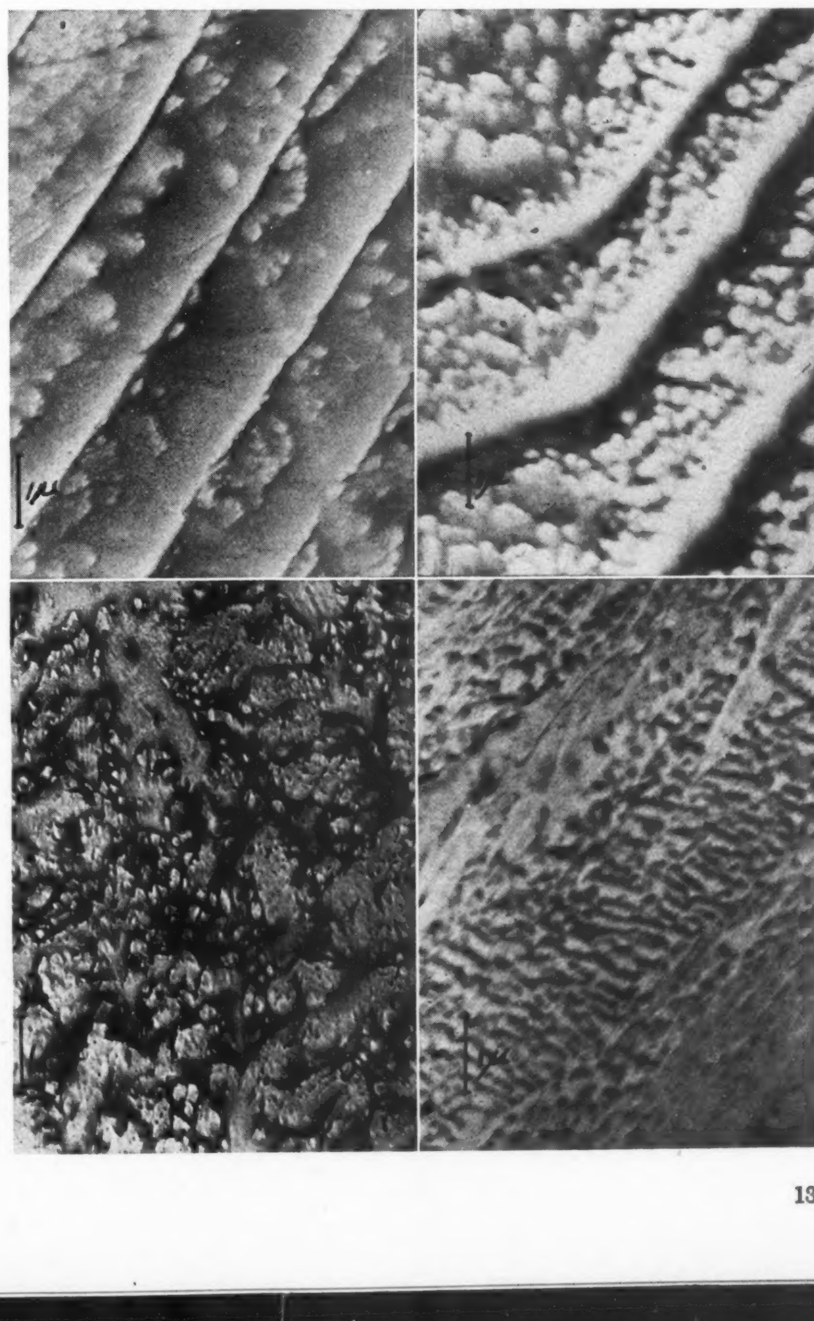
*Abstract of a paper presented as a progress report at the recent Chicago meeting of the American Institute of Mining and Metallurgical Engineers.

†150 Angstrom units is approximately .00000059-inch.—ED.



Left and right—Pearlite in eutectoid steel at a magnification of 20,000. Difference in appearance is due to orientation of the cementite lamella which in the right-hand view are nearly parallel to the surface

Below—High-purity copper at magnification 10,000, after cold-working. Upper views show slip lines produced by 5 per cent compression, lower views are after 72 per cent compression, polished surface being perpendicular to plane of compression



then appear thin and transparent to the rays, while the fins, which present the film obliquely or edge-on to the beam, appear opaque. Projecting fins on the metal, which make narrow grooves in the polystyrene, register similarly. Abrupt steps at differences in level of the metal surface give dark lines. For example, if particles of one phase in a two-phase alloy stand in relief above the surface or are depressed below the surface they are surrounded by dark lines. Indirect evidence can frequently distinguish elevations from depressions.

Interpreting Patterns

The etched surfaces of single-phase metals and alloys frequently exhibit structures of remarkable interest, as will be seen from the accompanying illustrations. It may be possible that the patterns produced are in some way related to galvanic effects in the etchant, but it seems more probable that the effects are due to variations in perfection of the crystalline grain, since the patterns obviously change with grain orientation. The attack of the etching solution appears to be fastest along the boundaries of domains much smaller than grains, which in copper are rod shaped and in monel metal are equiaxed.

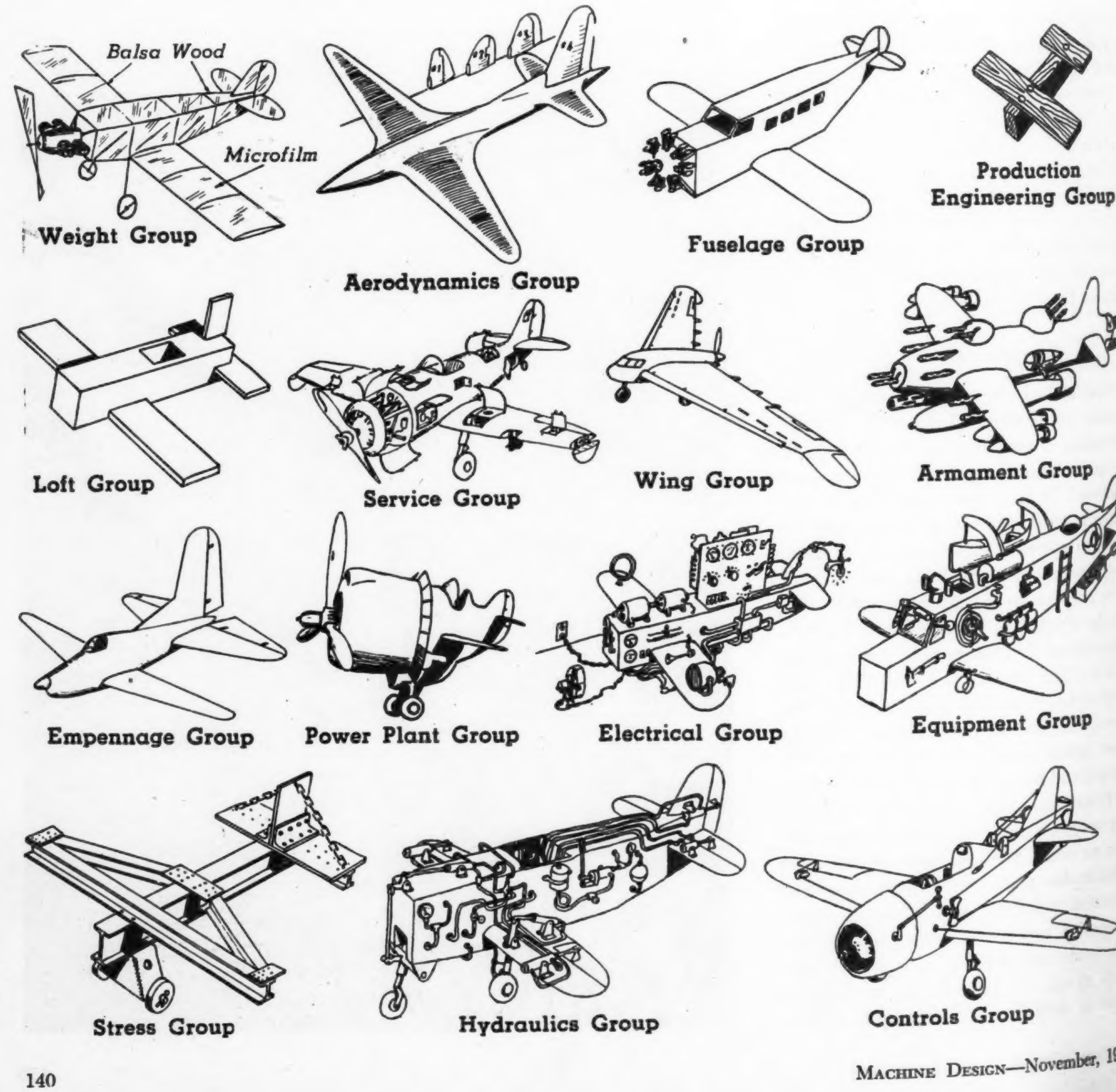
Precautions that must be taken in microscopy at high magnification are important with the electron microscope. This applies particularly to the need for repeated polishing and etching (each successive polish becoming less severe and each etch lighter), since the final etch should in general be no heavier than is used for oil-impression optical

microscopy and in many instances should be much lighter. An extremely light etch, of course, is incapable of cutting through a flowed layer if the flowed layer has appreciable thickness.

Replicas used were of silica, deposited upon polystyrene and floated from the polystyrene in ethyl bromide according to the method of Heidenreich and Peck. The samples were mounted in bakelite, polished and etched, then the polished bakelite surface was given a very slight coat of beeswax in ethyl bromide and placed in a mounting press under powdered polystyrene. The press was heated to 150 degrees Cent. before applying pressure, then cooled to 70 degrees Cent. while under a constant pressure of 3000 pounds per square inch. The bakelite-polystyrene interface then cleaved apart easily, exposing the molded replica of the specimen surface, on which the silica was deposited from a tungsten conical filament in a small chamber evacuated by an oil diffusion pump. All plates were exposed at magnifications of 2000 to 6300 and subsequently enlarged.

Specialization with a Vengeance!

HUMOROUSLY sketched below are a number of airplane designs envisioned by C. W. Miller, engineer for Vega Aircraft Corp. as he believes each engineering group would design a plane according to its primary interests. Depicting gadgets for the equipment group, impractical lightness for the weight group, simple standard sections for the stress group, accessibility for the service group, simplicity for the production group, etc., his drawings effectively show "dream" airplanes evolved from pet theories. This is Yankee ingenuity run riot!



Duplicate Tracing Minimizes Drafting Work

By John W. Greve

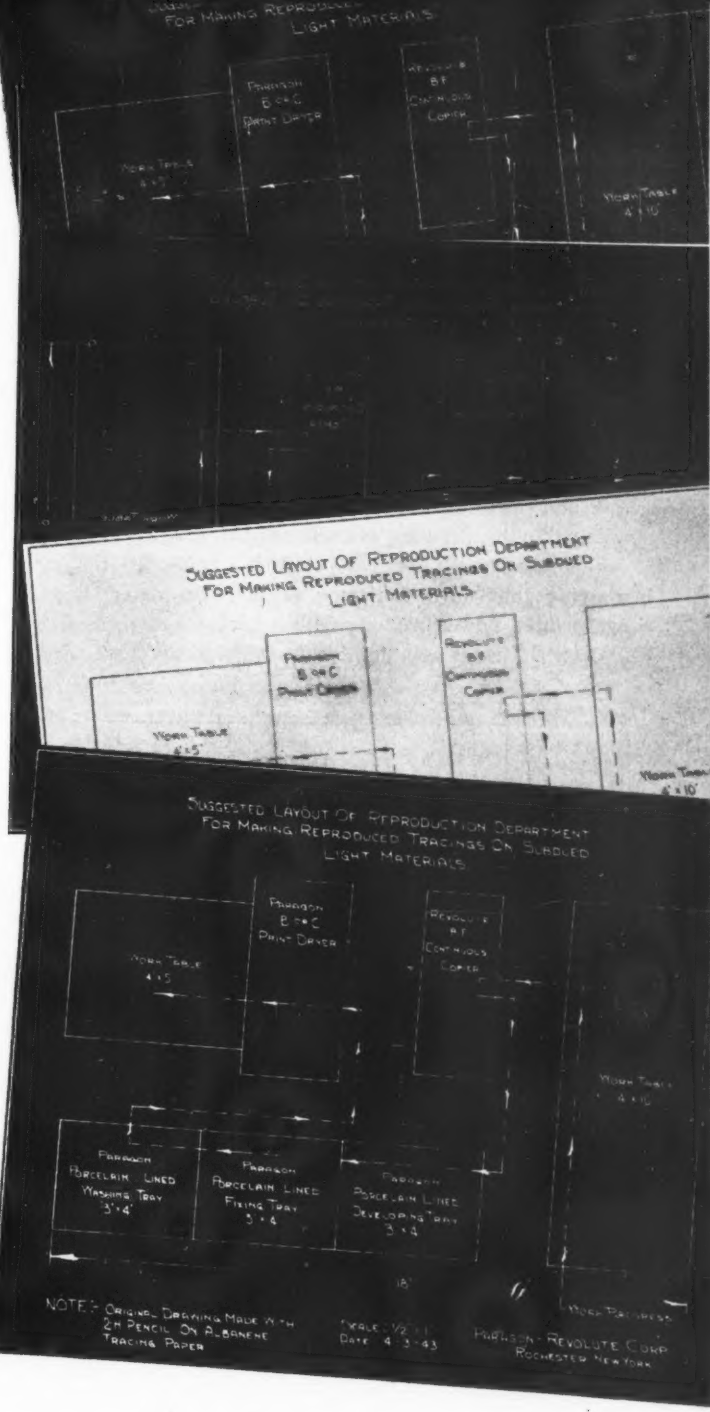


Fig. 1—Comparative facsimiles of blueprints made direct from a pencil drawing and from a duplicate tracing, shown at top and bottom, respectively. Interposed are the negative made from the pencil tracing and the duplicate made from the negative. Considerably more strength is obtained from the duplicate because of its opaque lines. In the top print the lines were beginning to burn through, necessitating a too-short printing time. Duplicates are on K & E Photact

TIME is vital in the drafting room both because drawings for approved designs must be printed quickly as well as clearly for the production department, and manpower is not generally available in most engineering departments for making ink tracings. For these reasons, recently improved methods for producing opaque-line duplicates of pencil drawings without the time-consuming and tedious task of "inking" and checking against the original merit careful consideration as a means of obviating a bottleneck in the drafting room. Also, design changes may be made readily on a duplicate without altering the original master and without redrawing.

Semiphotographic methods for duplicating pencil drawings have been improved recently and produce commercially satisfactory results. Sepia negatives and similar methods are also utilized for this purpose although the quality, generally, of the original drawing must be good. Sepia negatives from pencil drawings have slightly transparent backgrounds. If the background were of proper density, the fine lines would be completely burned out.

Although prints from semiphotographic duplicates of pencil drawings do not have the same quality as those produced from tracings made with india ink, they are far superior to those made direct from a pencil drawing as in *Fig.* 1. Further, the duplicates may be printed any number of times without impairing their original quality which is far from true with pencil drawings. Quality of prints depends upon the degree of contrast between the opaqueness of the pencil lines and the translucency of the paper or cloth. Handling of pencil drawings invariably rubs off some graphite from the lines, reducing their opacity and smudging the tracing, thus reducing its transparency. For this reason each succeeding print from a pencil drawing becomes less satisfactory.

For the reasons just mentioned, it is best to make duplicates of pencil drawings as soon as possible after the drawing is finished. To wait until the design is approved or in some cases until the pilot model has been produced introduces complications that may render redrawing necessary. At least the quality of the duplicate, and therefore that of the resultant prints, is inferior compared with duplicates from "fresh" drawings.

Semiphotographic duplicates are silver-image prints involving the use of negatives in their production. High-contrast emulsions are employed so that all lines are opaque. In this method the line either is reproduced opaque or there is no line. No halftones are obtained, thus assuring that a uniform printing quality will be ob-

tained. If the duplicate has broken lines, it was underexposed or had poor contact. If the lines have grown in width it was overprinted. Proper balance will produce a good print provided the original has sufficient contrast.

Whether prints are to be made by blueprint, black and white, ammonia vapor or other direct processes, this in itself is an advantage by virtue of the fact that uniform printing time may be employed. Variations in quality of pencil drawings on the other hand would necessitate fussing to obtain the best print possible or even a readable one in some instances. Where less-than-usual-skilled operators are employed, as is frequently the case under wartime conditions, this factor takes on added significance.

When restoring faint pencil drawings, it is necessary to over-print the drawing considerably to give the duplicate sufficient strength for blueprinting. Lines on the same drawing that have sufficient strength, however, become overprinted and reproduce with a fuzzy growth, as shown in *Fig.* 2. This is a limitation imposed by the extreme

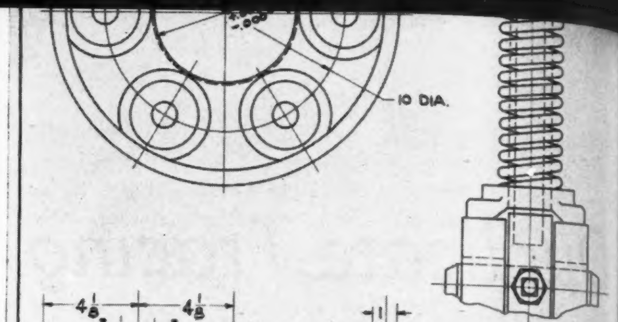


Fig. 2 — Left — Duplicate of pencil drawing may be produced on linen from a semi-photographic negative. Sections requiring alterations are opaqued on the negative and redrawn on the duplicate

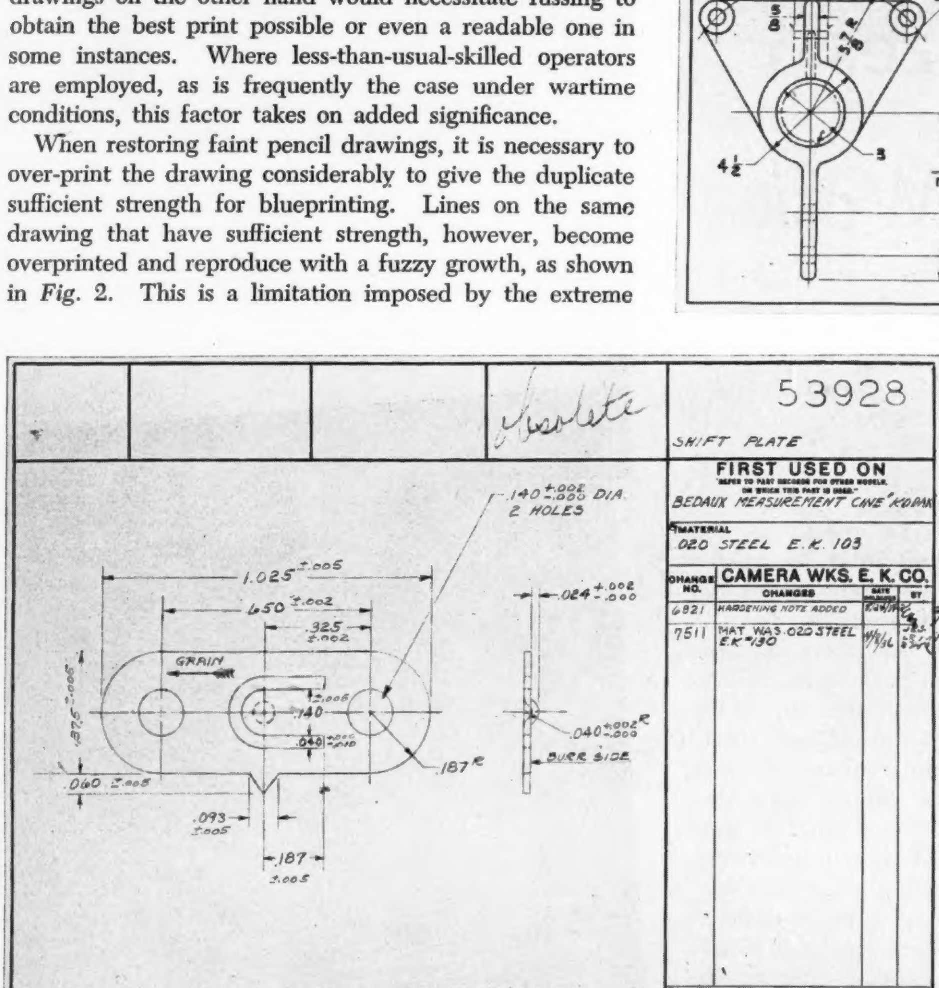


Fig. 3 — Above — Duplicate tracing on cloth produced from an ink original and a sepia negative. Image may be deleted readily for changes by rubbing with a damp eraser

range of the original because an opaque image is desired from the weakest line on the drawing.

In drawing originals, a considerable investment in time is involved. Therefore production drawings and those requiring a number of easily readable prints should be drawn on the best medium available. Excellent papers and cloths have been developed with a good, fine tooth for taking sufficient graphite from a pencil. When quality of prints and investment in drawing time are considered, there is every justification for the use of cloth for production drawings even though cloth costs roughly eight times as much as tracing paper. Cloth for pencil takes graphite in heavy, black lines even from a 7H pencil.

Some users prefer white cloths or vellum to tints for pencil work because the tints are believed to reduce the contrast of the lines. Users generally prefer 3H or 4H pencils for lines and H or 2H for lettering, depending upon the pressure exerted by the draftsman. Drawings made in this way have been satisfactorily reproduced with sepia negatives, which are less expensive than photographic. They require, however, drawings with excellent printing contrast. Relative costs are \$.60 compared with \$.98 for photographic contact and \$1.60 for projection.

Reproduced tracings on waterproof cloth are required by many government departments from their prime contractors. For instance the Navy requires seven such tracings. Obviously duplicate tracings are worthwhile for this and eliminate the possibility of deviations or errors in individual copies. Tracings also have been satisfactorily produced from blueprints by the photographic method, obviating the necessity of making a tracing by hand.

Probably one of the most useful time-savers involves alterations, whether the original is ink or pencil. Duplicate tracings may readily be altered to take care of design changes, model changes, etc., without the necessity of redrawing. This is particularly helpful where complicated drawings need relatively few changes. Two methods are in general use. One involves blocking out the negative

where changes are to be drawn. The subsequent duplicate then can be inked in for the altered design. The second method involves erasures on the duplicate itself. The image is easily removed with a damp eraser or sometimes dry even though the image seemingly will withstand any amount of ordinary abrasion. On ammonia-vapor prints, a corrector fluid is used. A third method is advantageous when entire sections are to be deleted. After the print is exposed these sections to be printed are covered with an opaque sheet and placed in the printer a second time. This burns out the exposed portions and the print made from the negative will be clear in the sections to be altered. Some drafting rooms find it advantageous when altering linen prints, *Fig.* 3, to rough the surface slightly with a dry eraser after the image has been deleted to restore sufficient tooth for the subsequent drawing. Two solution eradicators, however, leave the surface in good condition.

Duplicates produced in a vacuum frame printer are assured of contact between tracing and negative over the entire surface, minimizing blurred lines and line growth which would result if there were the slightest separation from the negative. Negative then is the same size as original. Tracings produced by this method are restricted to the size of frame available unless the exposure is made in sections. Continuous printing is also satisfactory and is not limited as to the length of print. With this method of printing, however, it is essential that good contact be maintained betweeen tracing and negative, as well as between negative and sensitized duplicate, to assure a sharp, clear reproduction, similar to that obtainable in a vacuum frame. If enlargement or reduction is required a camera is employed for projection. If enlargements or reductions are desired and this is known at the time the original drawing is made, allowances should be made for weight of line and size of lettering, allowing for line growth.

If reproductions are to be made from originals which are opaque or have printing on the reverse side, a camera is utilized. Often, however, printing by the reflex method is employed. This method is similar to contact printing except that a yellow filter is interposed between the light source and the reproduction material. The original is placed facing the light and in contact with the emulsion side of the negative. The light thus goes through the sensitized material and is reflected back through it from the original—the black lines absorbing the light and the clear sections reflecting it. Exposure time is about half that of regular contact printing and negative is processed in the same manner as in the standard method. Processing, however, is more critical because contrast is sacrificed by the fact that the negative has been flashed overall with the passing of the light through it.

Worthy of consideration for many uses is a tracing cloth with a photographic emulsion. Photographs of assemblies may be printed on this cloth as shown in *Fig.* 4 and then dimensions, instructions, and other information may be lettered in by the draftsman. In addition to saving the draftsman's time which otherwise would be needed for a detail assembly drawing, this method has the advantage of being readily understood by new shop men who are untrained in the reading of prints. The aid to them by reducing confusion has proved a big boon in many war plants. Lockheed Aircraft believes this method means almost as much to them as their templet photography. The limitations of the method, however, require that the photograph show the relation of all the parts to each other.

Many plants have adopted the precaution of microfilming all their drawings, often in duplicate, and of storing these copies in vaults at remote locations for safe keeping. At the time of air-raid precautions this procedure became increasingly popular. Strangely enough companies found that microfilming of pencil drawings could be projected to produce prints superior to the original. Usually satisfactory projection is limited to about 16 diameters. Line growth is experienced on such prints, probably due to limitations of the optical systems and the overprinting required for opaque lines. Postwar developments no doubt will greatly reduce the limitations of the former, probably with glass-coated, parabolic plastic lenses and finer grain developers.

A new development that will receive postwar attention is a Dutch process for reproduction that is now reported to be used by the government. Clean, sharp prints are obtained almost automatically by an electronically-controlled printer and printing emulsions are said to have better latitude for good reproduction.

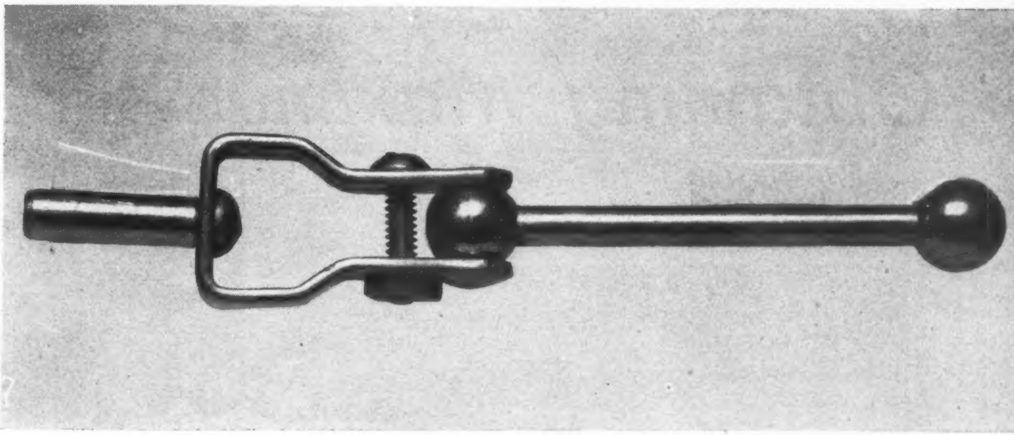


Fig. 4—Photographic emulsion on tracing cloth conserves draftsman's time through use of photographs for assembly drawings and has proved a boon to many shops. Dimensions and instructions may be lettered on the tracing

Cooperation of the following companies is greatly appreciated for information and illustrations included in this article: Charles Bruning Co.; Eastman Kodak Co., *Figs.* 2 and 4; Eugene Dietzgen Co.; Keuffel & Esser Co.; The Frederick Post Co., *Fig.* 3; Ozalid Products Div.; Paragon-Revolute Corp., *Fig.* 1, Remington Rand Inc.

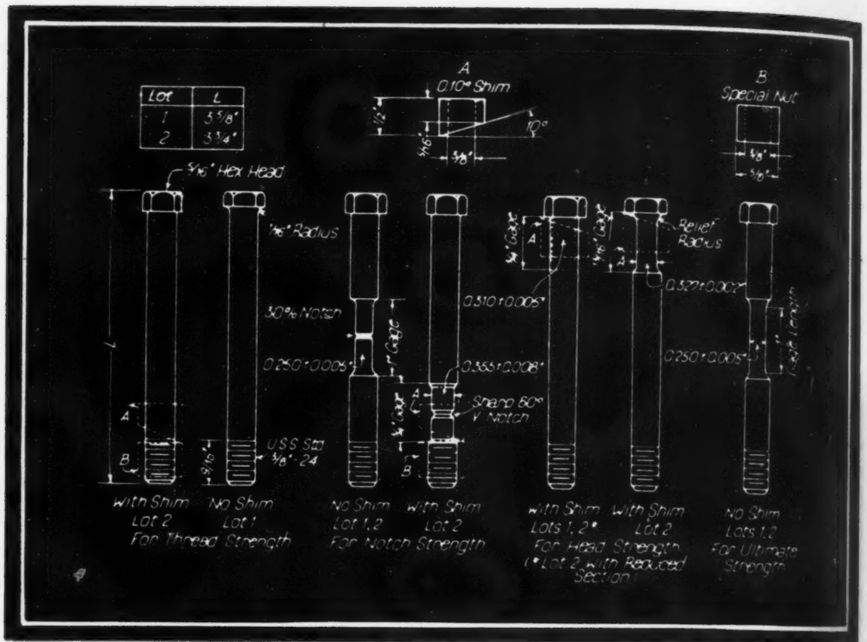


Fig. 1—Standard nickel steel aircraft bolts were tested as received and in specially machined modifications at various strength levels

Obtaining Maximum Bolt Strength

ALTHOUGH nickel steel bolts which have been heat treated for highest tensile strength and hardness fail in the threads under pure tension, addition of some bending transfers the failure to the head. How to develop maximum strength under such conditions is described in the accompanying article, abstracted from a paper presented at the twenty-fifth annual meeting of the American Society for Metals, held in Chicago

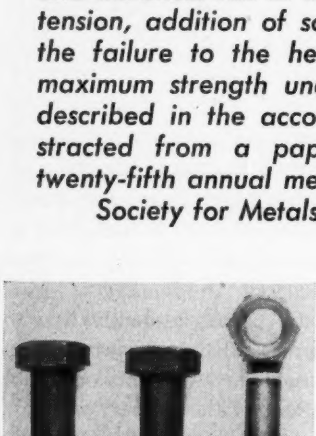


Fig. 2—Shows typical failures of bolt specimens: Thread break at extreme left, notch break in center and head break at left

By G. Sachs, P. S. Cole and R. A. Roth*

RECENT investigations on various alloy steels have shown that sharp notches reduce materially the strength and ductility of cylindrical test bars if the ultimate strength or "strength level" of the steel exceeds a value of approximately 200,000 pounds per square inch. Tubing subjected to internal pressure exhibits a similar, but not quite as pronounced, "embrittling effect" if the strength level of the steel exceeds a value of approximately 150,000 pounds per square inch. Cylindrical notched bars and bolts also have been found to break at reduced loads, in a brittle fashion, if their strength level was above 150,000 pounds per square inch, also if a bending strain was superimposed upon the applied tension by means of shims placed under the heads of the test bars or under the nuts of the bolts. It was the particular purpose of the investigation discussed in this article to clarify some of the factors which might cause embrittlement of high-strength alloy steel bolts.

Commercial aircraft bolts, fabricated from SAE 2330 steel, were selected for the investigation. The most important fundamental factors influencing their strength were as follows:

1. Various strength levels, as determined by the tem-

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pering procedure after proper hardening

2. Various shapes of the head, which was found more prone to rupture than the thread, in the range of conditions conducive to brittle breaks
3. Various types of loading—regular tension and tension with super-imposed bending.

Two lots of SAE 2330 bolts, ⅜-inch diameter by 3⅝ and 3¾ inches total length, respectively, *Fig.* 1, were used for the investigation. They were heat treated by quenching from a vertical furnace containing a forming gas atmosphere into an airlift quenching tank followed by tempering

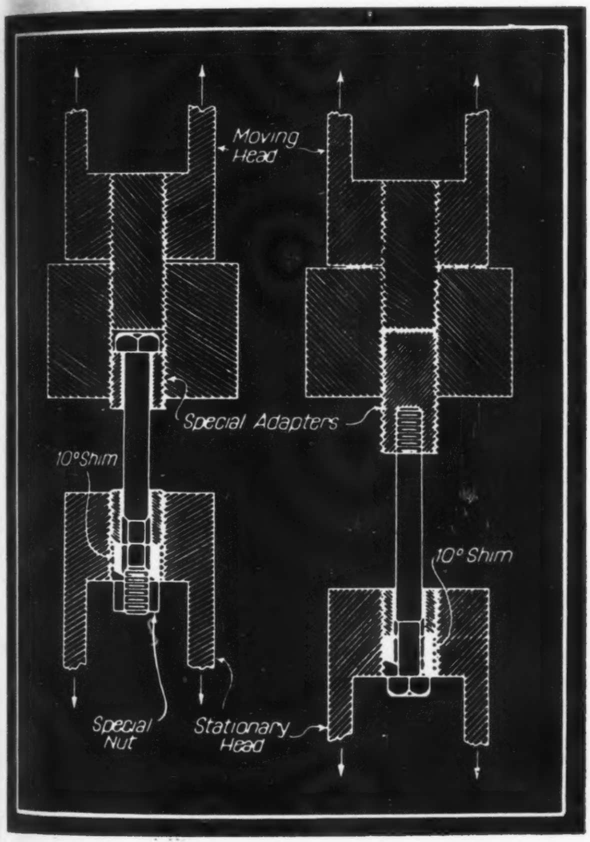


Fig. 3—These fixtures were used for testing bolts under combined tension and bending

at various temperatures for an hour in an electric forced air convection type furnace. The hardening temperature, 1500 degrees Fahr., was maintained for one-half hour. All specimens were machined before heat treating, hence the results apply to a steel with a decarburized surface.

In an early stage of the investigation it was observed that various failures of the bolts occurred under different conditions, *Fig.* 2. Two major types of failure were recognized: (a) Breaks through the thread, and (b) breaks under the head.

In addition to tests on bolts in the shape supplied, tests were made also on bolts reduced in section at various points, *Fig.* 1. Some such specimens were provided with a 60-degree sharp notch, which removed 30 per cent of the cross-sectional area of the reduced section. Further series of tests were made on bolts with an increased radius machined under the head. Also the ultimate strength was determined by testing specimens with a reduced cylindrical section.

Thus, four different strength characteristics of the 2330 steel in various conditions of heat treating were determined:

a. Strength through the thread or "thread strength"
b. Strength under the head or "head strength"
c. Strength through the notched section or "notch strength"
d. Ultimate strength or "strength level" of a cylindrical section.

With the exception of the cylindrically machined bars, all other types of test bars were subjected to tensile tests in two ways:

a. By means of regular ball-seat fixtures
b. With a tapered shim or washer having an angle of 10 degrees.

The tapered shim results in eccentric loading of the test bar, or in a superposition of bending on the applied tension. This eccentricity will be higher in the sections close to the shim than in sections farther away. This enables one to apply a higher eccentricity to the thread (or notch) than to the section under the head and vice versa, *Fig.* 3. The rolled thread, as well as the corners under the head, and also the machined sharp notch and machined head fillet had a radius of approximately .002 to .003-inch.

Results of the various series of tests are plotted schematically in *Figs.* 4 and 5 against the tempering temper-

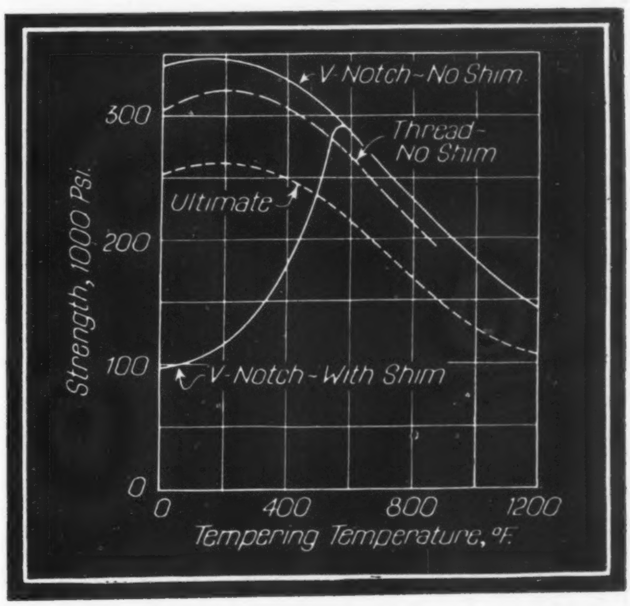


Fig. 4—Summarizes in schematic form the results of thread and notch tests on nickel steel aircraft bolts

ature. Thread strength and notch strength, *Fig.* 4, in tests without shim, were almost identical for a given condition. This confirms the previously recognized fact that threads and compound notches behave much the same way as a single notch of the same contour and depth.

Throughout the whole range of the investigated strength levels, both the thread strength and notch strength are 25 to 35 per cent higher than the ultimate strength. The

absence of low strength values in these series of tests means that the threaded section of SAE 2330 steel bolts is not susceptible to embrittlement for any possible heat treatment or strength level, if subjected to regular tension with little or no eccentricity.

However, if a shim is added under the nut, the bolts were found to possess a much lower strength than without a shim. In the series on threaded bolts, irregular results were obtained and the thread stripped in all tests. A shim under the nuts of bolts provided with a notch close to the thread resulted in low notch-strength values at the highest strength levels, being less than 40 per cent of the ultimate strength, *Fig.* 4. With increasing tempering temperature the notch strength increased rapidly, ultimately becoming practically the same as that of bars tested without shims.

Section under the head was found to be more susceptible to embrittlement than the thread, *Fig.* 5. In the as-quenched condition, all test bars failed in a cup-like

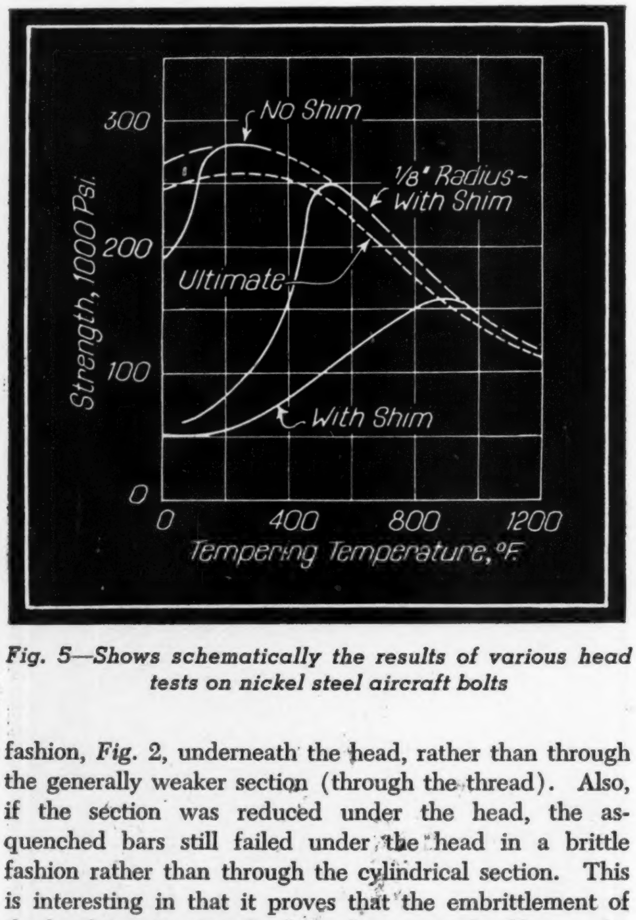


Fig. 5—Shows schematically the results of various head tests on nickel steel aircraft bolts

fashion, *Fig.* 2, underneath the head, rather than through the generally weaker section (through the thread). Also, if the section was reduced under the head, the as-quenched bars still failed under the head in a brittle fashion rather than through the cylindrical section. This is interesting in that it proves that the embrittlement of the head is not primarily dependent upon the fiber as determined by the heading process but upon the notch effect of the head contour.

Increasing Head Strength

In order to obtain a thread failure for the as-quenched condition, the radius under the head was increased by machining off a part of the head, from a few thousandths of an inch to 1/16-inch, *Fig.* 1, thus increasing considerably the strength of the section under the head when conditions are conducive to brittle failures.

Tests with a shim under the head also showed that the section under the head was more liable to embrittlement than the thread, *Fig.* 5. Head strength for the high-strength levels, if tested with a shim, was as low as 20 per cent of the ultimate strength. Only when the strength level decreased to 160,000 pounds per square inch or lower did the head strength become identical for bolts tested with and without the shim, the failure then occurring through the thread or in the reduced section, if any.

Again, it was found that this embrittlement could be reduced materially by machining stress relief radii under the head, although even a radius of ⅛-inch did not eliminate completely the effect of the shim. However, it raised the range of strength levels which were not susceptible to brittle head breaks to approximately 240,000 pounds per square inch, *Fig.* 5.

Results Are Summarized

1. In tension, with little or no superimposed bending, ductile breaks occur through the threads except in the as-quenched bolts.

2. As-quenched bolts show brittle failures under the head at low and widely scattered loads, thus indicating greater notch sensitivity at this point than exists in the threads.

3. Failures under the head can be prevented by adding a "stress-relief" radius from shank to head. If necessary in practical cases, this may take the form of a semicircular groove having a radius of one-eighth to one-sixth of the shank.

4. Superimposed bending at either the head end or thread end causes brittle failures in these sections at considerably reduced loads. For a 10-degree shim under the head, brittle failures occur at the head for tempering temperatures below 800 degrees Fahr. or strength levels above 160,000 pounds per square inch.

5. For a shim under the nut, failures occurred at low loads by stripping of the threads in an apparently brittle manner. Only for tempering temperatures above 1200 degrees Fahr. did the thread reach approximately the same strength when tested with a shim as without.

For tempering temperatures less than 400 degrees Fahr. (strength levels above 250,000 pounds per square inch), brittle failures were obtained through a .002-inch-radius notch placed near the nut and tested with a shim under the nut.

6. Brittle breaks under the heads are suppressed by the use of a relief groove. Commercially feasible radii (1/16-inch) permit superimposed bending without impairment at levels up to 225,000 pounds per square inch.

7. The as-quenched bolt showed a lower tensile strength and a greater tendency toward brittle failures with superimposed bending than a bolt stress relieved by tempering at 200 to 400 degrees Fahr.

8. Bolts of the selected steel and size may be heat treated to 250,000 pounds per square inch if the straining in service is to be in pure tension, but 175,000 pounds per square inch is the maximum safe limit if superimposed bending is present.

9. A greater strength level may be used in the presence of superimposed bending if a fillet is used under the head. Possible improvement may result from the use of fillets in the thread bottoms.

MACHINE *Editorial* DESIGN

Design Field Wins Increased Recognition

IT is doubtful whether the standing of the design profession has ever been as high as at present. Chief engineers and designers are not, as a rule, aggressively voluble, and their concentration of purpose has tended in the past to minimize the credit which is their due.

Outstanding achievements in design of war equipment and machines for producing it have, however, wrought a change. No longer do machinery companies hesitate to name the engineer who is primarily responsible for the development of a specific type of machine that has proved invaluable—in this "war of machines"—to the progress of the fighting forces or to the production of equipment for them. Almost daily one hears of the accomplishments of individual designers, and on every hand can be seen signs pointing to the fact that design is rapidly assuming its rightful place.

Among the evidences of this current recognition are the numerous items of information published by machinery manufacturers in which are sung the praises of the engineering staffs. There also are the reports of visitors to the battle fronts in which American equipment is rated as second to none. Then too there are the plans of some of the leading engineering societies to accord the design profession due recognition through the establishment of design divisions within their organizations.

The designer has had his opportunity. In seizing it he not only has performed yeoman service for his country but has raised his prestige to a new level. He still has the chance to develop equipment that will bring the war to an earlier close. And he has other opportunities ahead—unsurpassed in peacetime history—to develop new machines of all types that will go far toward bringing order and well-being to a disrupted world.

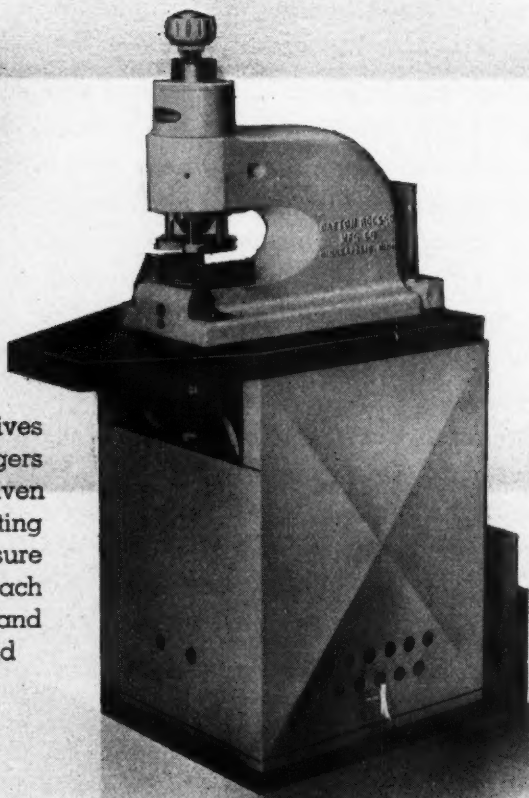
Materials Work Sheets

DESIGN engineers have long felt the need for a single source of information to which they could turn for assistance in the selection of materials. Handbooks, catalogs and technical bulletins have been of some help but usually have fallen short in supplying complete data.

To remedy this situation MACHINE DESIGN *inaugurated in the October issue its series of Materials Work Sheets. The response from readers already has proved that this type of comprehensive information is eagerly sought, and indicates that the series will prove of inestimable value in the specification of design materials.*

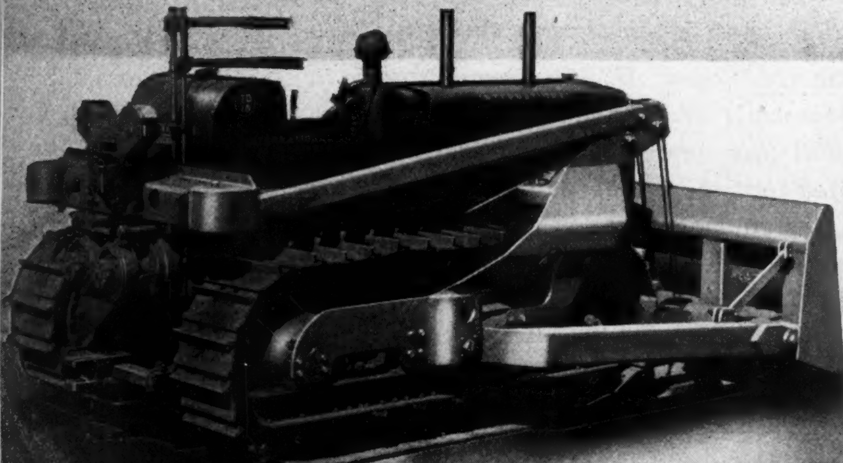
L. E. Jermy

Left—Made of stainless steel, the disk spindle of Bridgeport's cut-off machine is mounted in extra wide grease-packed ball bearings and driven by motor which is positioned to balance the disk assembly. Coolant is fed by vane-type pump through flexible rubber hose. Guard shown is transparent plastic

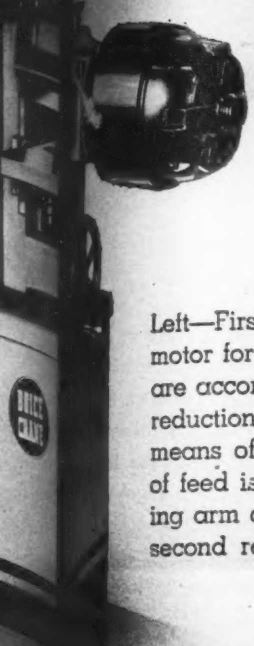


Right — Solenoid-controlled clutch drives mainshaft from flywheel on Dayton Rogers piercing press, the ram of which is driven off eccentric on mainshaft. Nonrepeating knockout mechanism is utilized to insure only one work cycle taking place for each solenoid impulse. Hinged guard makes and breaks electric circuit to clutch solenoid

Below—Lifted by means of cables threaded through sheaves to a double drum winch, blade and blade arms of Heil cable dozer are of welded plate construction, the blade being high-tensile carbon steel. Unit is mounted on International Harvester tractor, the tread wheels of which are gear driven



Right—Driven through chain and change gears, the spindle speed of Thompson automatic profile miller is variable. Cam controls traverse and feed of work table, rotation of which is accomplished through hardened and ground worm gear. Disk with adjustable lugs is employed to control work cycle



Left—First two of the speed reductions from motor for feed of Boice-Crane thickness planer are accomplished through V-belts, second two reductions through gears and last reduction by means of roller chain. Starting and stopping of feed is controlled by lever-regulated pivoting arm on which are commonly mounted the second reduction driven pulley and third reduction driving pulley

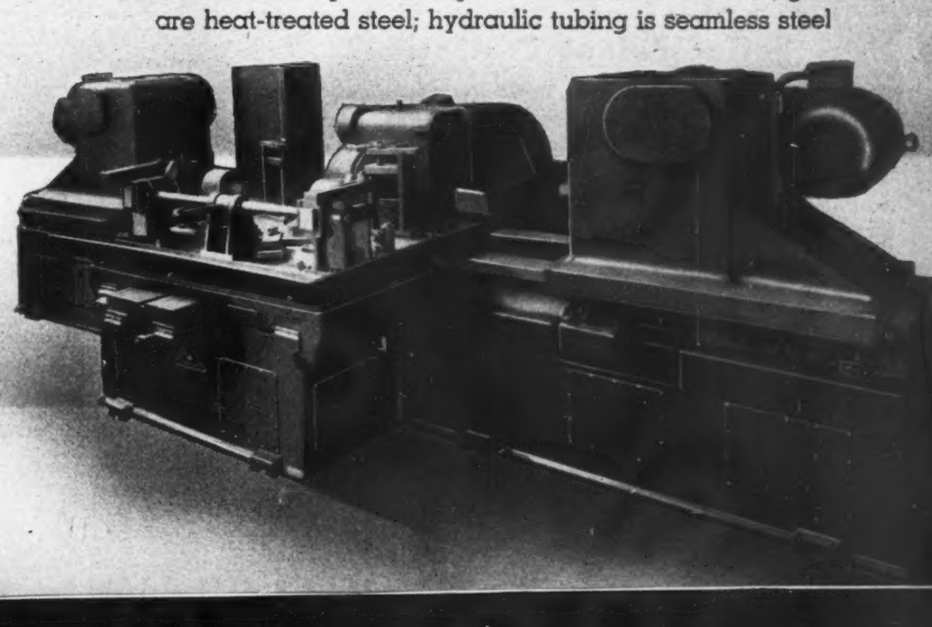
M es

in Guns

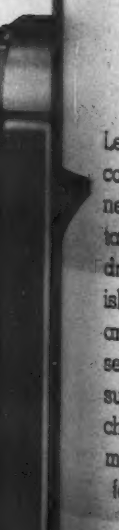
(For new ... page 228)

Left—Cylinder and end plates of motor for Aro pneumatic hand drill are nitride-hardened alloy steel, ground and lapped to mirror finish. Rotor is four-bladed type with blade slots off center. Housing is molded plastic

Below—Controlled by solenoids in combination with limit switches, pumps and boring bars on LeMaire 3-way boring machine are motor driven through V-belts and gears while tables are fed hydraulically. Main frame is cast iron; gears are heat-treated steel; hydraulic tubing is seamless steel



Left—Employing foot-pedal control for rotation and magnetization of chuck which is taper mounted and direct driven from motor, Lima polishing lathe has pedestal and motor frame of cast iron, self-contained rectifier unit supplying direct current for chuck magnetization, and magnetic disk-type brake for quickly stopping chuck



Design Roundup

Materials Availability

A SOMEWHAT EASIER situation with respect to ferroalloys should prove helpful to designers. Obviously there are still limitations as to uses. But more leeway is indicated, and on anything like essential work it appears that designers can revert, for some alloys, to more normal specifications. In other words there is now not quite the pressure to conserve on one alloy at the expense of another or, as has been the case in some instances, to employ an entirely different material.

For instance, regarding vanadium an appreciably better situation has developed. The acute shortage noted for some months after this country entered the war has eased under the development of mining properties, largely government financed. Actual production figures are being withheld but the gain is known to be substantial.

Moreover, customer requirements in some important directions also have eased, notably in high-speed tool steels. Actually, there is said to be a comfortable excess of stocks of these steels in this country—a development, interestingly, similar to that which began in England some time ago. The betterment in vanadium reflects also improvement in supply of tungsten and molybdenum and certain other important alloys, all closely interrelated; and by the same token, the better supply of vanadium has eased the situation in these other alloys.

The trend toward the use of normal analyses for materials for war work and essential civilian requirements should be reflected in increasing degree over coming months—although always subject, of course, to government limitation orders.

Better Patent Protection?

CONGRESS will shortly be asked to consider a series of bills which, their authors hope, will abate the increasing agitation by designers for better protection of their patents from infringement under present war conditions, and later.

Whether these bills are merely a recurring effort to solve the issue, or will lead to constructive action that will stand, is still in the future.

The first of these, by Representative Wadsworth of New York, H.R. 1213, broadens the legal safeguards of inventions used by the government or for the government. In substance, this bill would require the government in the case of any suit against it for payment for use of inventions, to make answer within 60 days after complaint has been filed. It would then require the government to dispense with certain obstructive legal tactics, forcing the government to admit material facts as disclosed by the records of the departments or their agents. Legal representatives of the agencies concerned would be compelled to assist claimants in getting material evidence from the records of such departments under certain defense safeguards.

The bill would further require maintenance by the government or its agencies of strict records of the use of inventions, as to time and ownership, with full reports to owners or assignees of patents; this clause would require full accounting for the time in which patents are classified on the government "secret" list and, further, a record of all examinations by any parties, of such files on patents.

Another measure introduced by the same author aims to facilitate transfer of cases in a given suit to the proper court, where suit is brought in a strange jurisdiction, and to eliminate unnecessary parties to such cases. This bill is H.R. 1372.

Two measures of considerable significance are companion bills in House and Senate, one by Representative Wright Patman, Texas, and the Senate version by Senator Harley M. Kilgore, West Virginia. The avowed purpose is the establishment of an Office of Scientific and Technical Mobilization within the network of existing Washington government.

The actual plan is to establish a government agency that would take over developments evolved during the war, through government-financed research, and make them available for public use; administer seized enemy patent holdings in the same manner, diffuse the findings of war research in major educational or scientific institutions, where these have been aided or financed federally, and to set up paid and volunteer bodies to act in an advisory capacity on technical problems concerning the government; review specifications, establish standards, recommend simplification, etc.

Stressed Surface Increases Life

FINISHES on aircraft engine parts have been coming in for considerable re-examination by designers and process men, who are coming to the conclusion that the mirror finish is not always the best finish when consideration is given to the improvement in fatigue life resulting from shotblasting or shot peening stressed surfaces. Important strides in this direction are being made, not only for steel, but aluminum as well.

Selecting Working Stresses for Combined Loading

By Joseph Marin
Pennsylvania State College

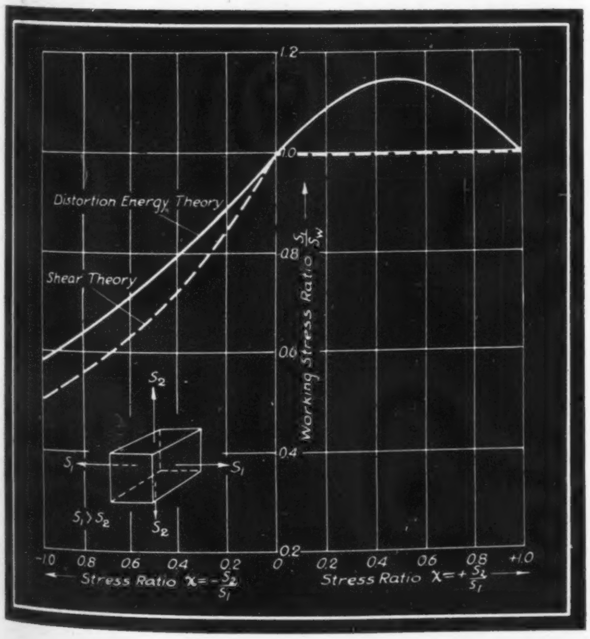
EFFECT of a combined state of stress on the strength of materials is one of the many factors to be considered in selecting the working stress value to be used in a particular design. This effect, though sometimes considered for static loads, is usually neglected for fatigue loads. Purpose of this data sheet is to summarize recent developments covering strength of materials subjected to combined stresses for both static and fatigue loads. To facilitate selection of working stress values by the designer, this information is presented in graphic form. It should be re-emphasized that only one factor, namely the effect on design of a combined static or fatigue state of stress, is considered. Furthermore, results apply strictly only to ductile materials.

Comparison of working stress values for two-dimensional static load

A TWO-DIMENSIONAL state of stress may conveniently be represented by principal stresses S_1 and S_2 as shown below. Stress S_1 is assumed to be greater than S_2. Then if the working stress in simple tension is S_w, according to the usual shear theory of failure(1)* the actual working stress is the smallest value of S_1 in one of the following equations:

$$\frac{S_1}{S_w}=\pm\frac{1}{1-x};\qquad \frac{S_1}{S_w}=\pm\frac{1}{x};\qquad \frac{S_1}{S_w}=\pm 1 \;\ldots\ldots\ldots\ldots (1)$$

where $x=(S_2/S_1)$.



This theory is used for ductile materials by many machine designers. It is the basis of the A.S.M.E. Code for the design of transmission shafting as well as more recently issued design codes. Working stresses by the shear theory, calculated from Equation 1, are shown by dotted lines on the graph at left. As an example of the use of this curve let it be assumed that the ratio of principal stresses is $x=-1$, that is, S_2 is a compressive stress numerically equal to the tensile stress S_1. The corresponding value of the working stress ratio is $S_1/S_w=.5$, from the graph. This means that if the working stress in simple tension is, say, 16,000 pounds per square inch the allowable stress value for S_1 is only 8,000.

Distortion Energy Theory

Recent investigations(2) show that for ductile materials the distortion energy theory agrees better with test results than does the shear theory. According to the distortion energy theory the working stress is the value of S_1 in the following equation:

$$\frac{S_1}{S_w}=\pm\sqrt{\frac{1}{x^2-x+1}}\;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Values of the working stress ratio S_1/S_w are shown by solid lines on the graph. Comparison of the two curves indicates the difference between these theories.

* References are listed on Page 153.

Comparison of working stress values for two-dimensional fatigue load

FOR a fatigue stress condition the A.S.M.E. code for transmission shafting affords an approximate means of considering a combined state of fatigue stress by assuming a fatigue stress to be equivalent to a static stress increased by 50 per cent. For the two-dimensional case of stress this assumption gives working stress values as shown by dotted lines on the graph at left.

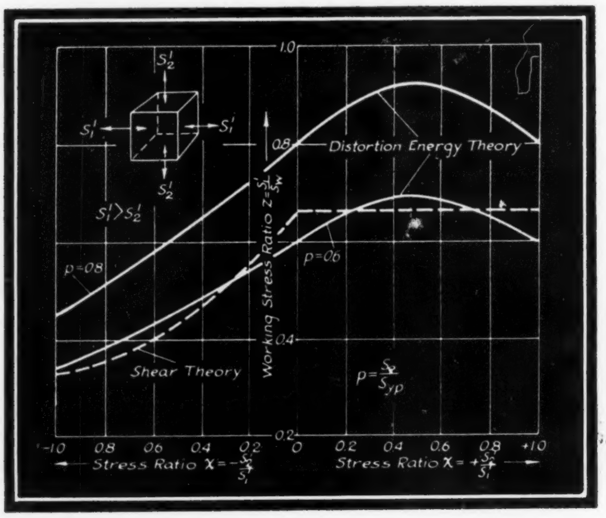
Using distortion energy as a criterion of failure, the author has developed equations (5) based on test results by Gough (4). For two-dimensional stress, if S_1' and S_2' are the maximum stress component and S_1'' and S_2'' are the corresponding average values, the working stress value for S_1' is:

$$\frac{S_1'}{S_w}=\frac{p}{\sqrt{1-x'+(x')^2}-(1-p)\dfrac{S_1''}{S_1'}\sqrt{1-x''+(x'')^2}} \quad \ldots\ldots(3)$$

where

$$x'=\frac{S_2'}{S_1'};\qquad x''=\frac{S_2''}{S_1''};\qquad p=\frac{S_e}{S_{yp}}$$

S_e = endurance limit for complete reversal in axial stress and S_{yp} = yield point stress in simple tension. Working stresses from Equation 3 are plotted as solid lines for the case of complete stress reversal, the average stresses S_1'' and S_2'' being zero. Values of p (ratio of endurance limit for complete reversal in axial stress to yield point in simple tension) are representative for ductile materials.

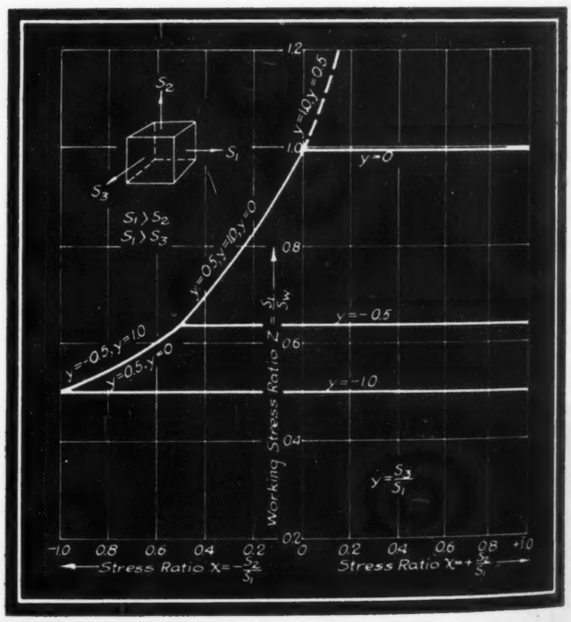


General state of stress, shear theory, static load

FOR three-dimensional stresses, according to the usual shear theory the working stress is the smallest value of S_1 in the folowing equation:

$$\frac{S_1}{S_w}=\pm\frac{1}{1-x};\qquad \frac{S_1}{S_w}=\pm\frac{1}{x-y};\qquad \frac{S_1}{S_w}=\pm\frac{1}{1-y}\quad\ldots\ldots(4$$

where $x=S_2/S_1$ and $y=S_3/S_1$. In Equation 4, S_1 is the greatest of the three principal stresses. Working stresses as given by this equation are shown plotted on the graph at right.

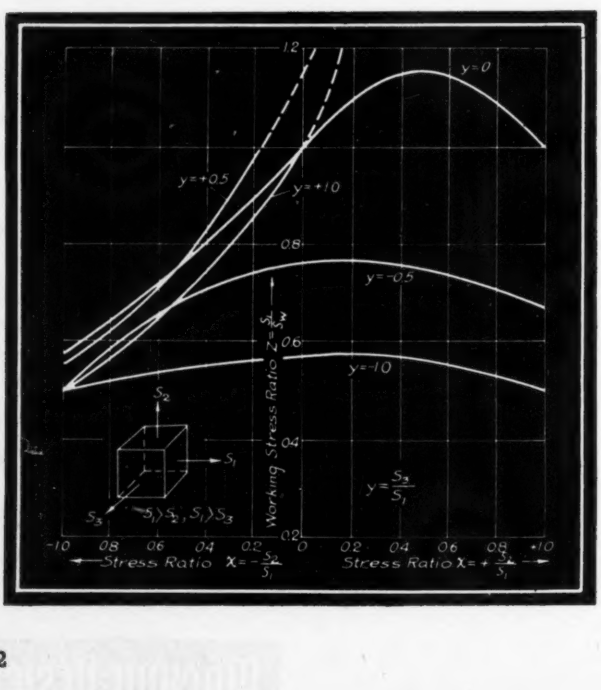


General state of stress, distortion energy theory, static load

FOR three-dimensional stresses according to the distortion energy theory the working stress value for S_1' is:

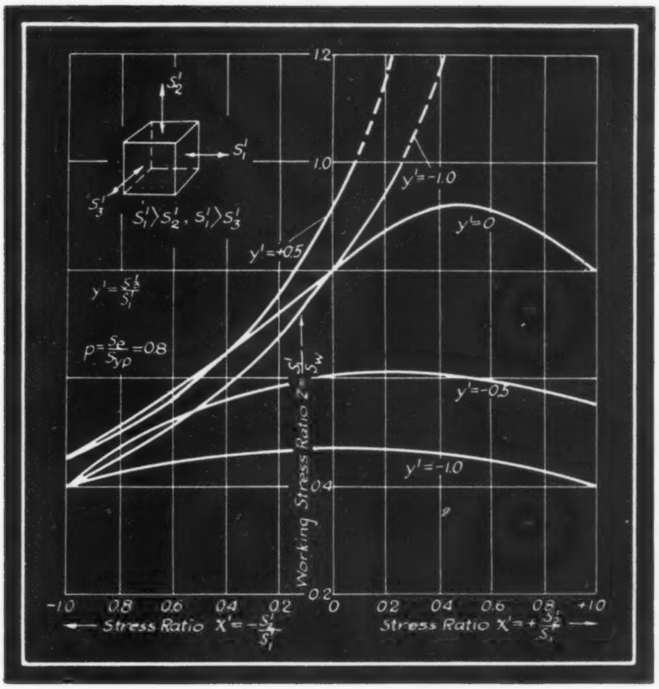
$$\frac{S_1}{S_w}=\pm\sqrt{\frac{1}{x^2-x+1+y^2-xy-y}}\quad\ldots\ldots\ldots(5)$$

Working stress values plotted from Equation 5 are shown at left.



General state of stress, energy theory, fatigue load

FOR three-dimensional fluctuating stresses, S_1' and S_1'', S_2' and S_2'', S_3' and S_3'' represent respectively the maximum and mean principal stresses. Then according to the energy theory (5) the working stress ratio S_1'/S_w is given by the following equation:

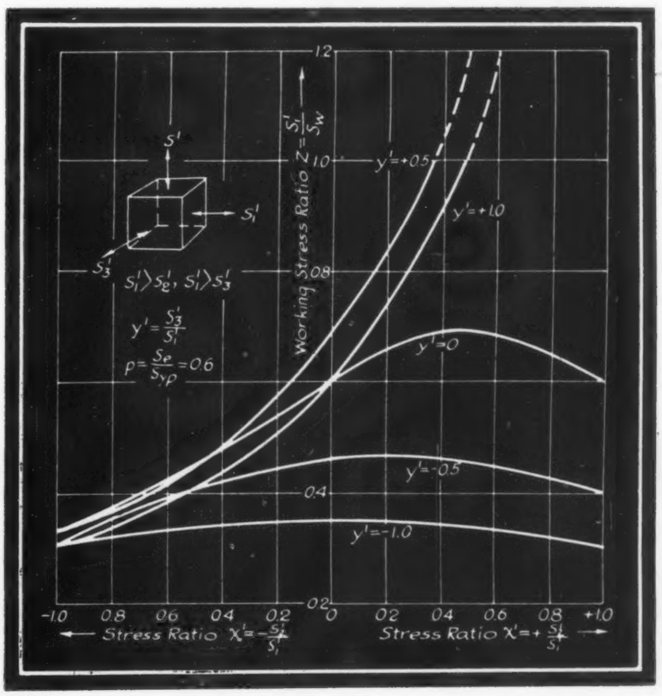


$$\frac{S_1'}{S_w} = \frac{p}{\sqrt{1+(x')^2+(y')^2-x'-x'y'-y'} - \frac{S_1''}{S_1'}(1-p)\sqrt{1+(x'')^2+(y'')^2-x''-x''y''-y''}} \qquad (6)$$

where

$$x' = \frac{S_2'}{S_1'}; \quad x'' = \frac{S_2''}{S_1''}; \quad y' = \frac{S_3'}{S_1'}; \quad y'' = \frac{S_3''}{S_1''}$$

Working stress ratios given by Equation 6 are shown on the accompanying curve sheets for two representative values of p (S_e/S_{yp}) and complete reversal of stress.



Recommendations

EXAMINATION of the graphs indicates that the working stresses are in some cases considerably less than the values used in simple tension. In other cases, apparently, working stresses could be greater than those in simple tension. However, since test results are not available for these cases of three-dimensional stress, it is recommended that in no case should working stress selected be greater than that used in simple tension.

For static stresses comparison between the shear and energy theories indicates that in some cases there is sufficient difference between the values given by these theories to warrant the use of the energy theory. Naturally the many uncertainties in design influence the importance of the above consideration in specific cases (6).

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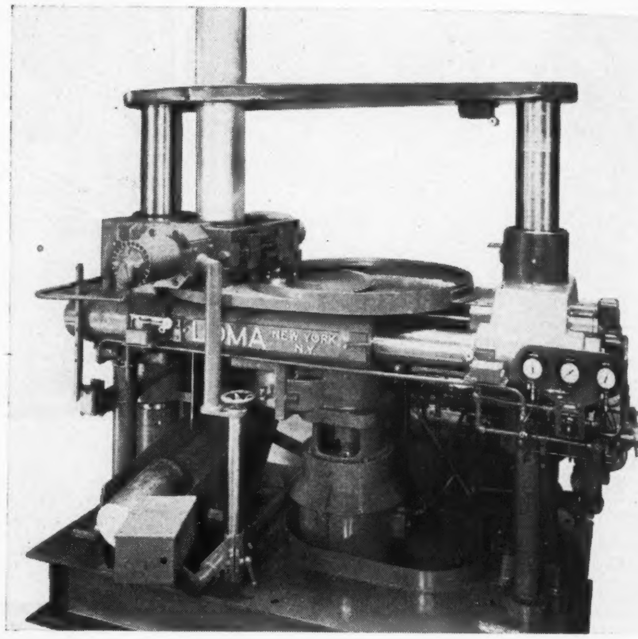
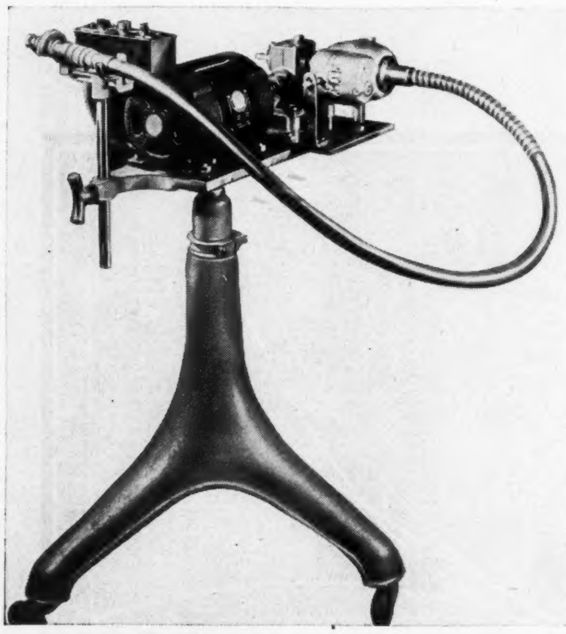
Applications

of Engineering Parts, Materials and Processes

Actuate Clamps for Automatic Saw

CLAMPS which hold the stock—billets or slabs continuously cast—as it is being cut by the Loma automatic saw, shown at right, are actuated by standard Hanna hydraulic cylinders. Operation of the saw starts when the stock is advanced to a level where its extremity intercepts the light beam of a photoelectric unit located in the rectangular box at lower left of the illustration. Clamping cylinders, which are visible just above and to the left of the saw blade, may be coupled so that stock is always held on the same center line or may operate individually to accommodate stock which is not perfectly straight or symmetrical.



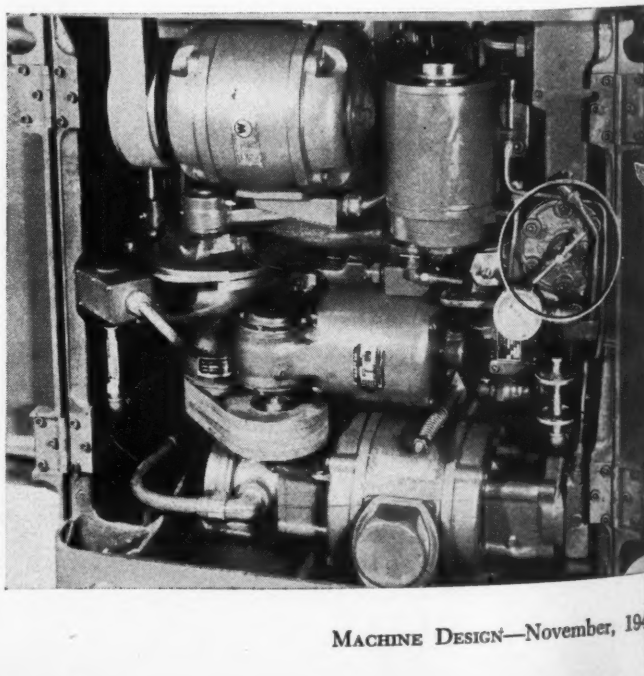


Speeds Up Thread Gaging

DESIGNED for gaging threads in airplane engine castings, the machine shown above employs a Walker-Turner flexible shaft and fittings. In operation, a thread gage is held in the handpiece of the flexible shaft and is driven clockwise into the threaded hole to be gaged. A light backward pull on the handpiece engages a reversing mechanism which causes the gage to disengage itself from the tapped hole. Made by winding consecutive layers of wire in opposite directions, one upon the other, the flexible shaft in this application transmits torque in either direction and also is used as a push-pull shaft to operate the clutch in the reversing mechanism.

Maintains Clean Hydraulic Fluid

PROTECTION of hydraulic operating system of Landis high-speed grinder for ball-bearing raceways, below, is furnished by compact Cuno filter shown encircled. Filter handles full flow (ten gallons per minute) of oil to a vane-type hydraulic motor which actuates the intricate cycle of grinding wheel movements. Pressure drop through the filter is approximately 5 pounds per square inch at an operating pressure of 150 pounds per square inch using oil of 200 Saybolt seconds universal at 100 degrees Fahr.



Materials Work Sheet

Filing Number 5.00

STAINLESS STEELS

AISI TYPES 302, 303 and 304

AVAILABLE IN: (302, 304) Sheet, strip, plate, bar, rod, forging billets, tube rounds, tubing, welding electrodes and core wire, tacks, spikes, wire, nails, screws, bolts, rivets, cold-drawn shapes, structural shapes.

(303)—Bar, rod, forging billets, screws, bolts, rivets, cold-drawn shapes.

ANALYSES:

Type	C	Mn	P	S	Si	Cr	Ni
302	.08-.20	2.00 max.	.04 max.	.04 max.	1.00 max.	17-19	8-10
303	.20 max.	2.00 max.	*	*	1.00 max.	17-19	8-10
304	.08 max.	2.00 max.	.04 max.	.04 max.	1.00 max.	18-20	8-10

* P or S or Se, .07 min.; Mo or Zr, .6 max.

PHYSICAL PROPERTIES

Data applies to all three types unless noted
Values are typical unless noted

ULTIMATE TENSILE STRENGTH

(*psi*)

..te, annealed	85,000	(302, 304)
..eet and strip		
Cold-rolled, ¼ hard, *min.*	125,000	(302)
Annealed, *min.*	75,000	(302)
Annealed	85-90,000	(304)
..ire stock		
Up to ½ inch dia., annealed	80-110,000	
cold-drawn	110-300,000	(302)
cold-drawn	110-150,000	(303)
cold-drawn	110-250,000	(304)
..r stock		
½ to 2-in. dia., annealed	85,000	
cold-drawn	110,000	
Over 2-in. dia., annealed	80,000	
..bing		
Cold-drawn, half hard	150,000	(304)
full hard	185,000	(304)
Annealed	85,000	(304)

YIELD STRENGTH IN TENSION

(*offset*=.2%) *psi*

..et and strip		
Cold-rolled, ¼ hard, *min.*	75,000	(302)
..nealed, *min.*	30,000	(302)
..e stock		
Up to ½-in. dia., annealed	30,000	
cold-drawn	50-275,000	(302)
cold-drawn	50-115,000	(303)
cold-drawn	50-225,000	(304)
..stock		
½ to 2-in. dia., annealed	30,000	
cold-drawn	60,000	
Over 2-in. dia., annealed	30,000	

ULTIMATE SHEARING STRENGTH

(*psi*)

..e stock		
When UTS 250,000 psi, cold-drawn	150,000	(304)
..r stock		
Over ½-in. dia., annealed	75,000	(302, 304)

FATIGUE ENDURANCE LIMIT

(*psi*)

Plate, sheet and tubing		
Annealed	35,000	(304)
Bar stock		
Over ½-in. dia., annealed	35,000	
cold-drawn	50,000	

ELONGATION IN 2 INCHES

(*per cent*)

Plate		
Annealed	50	(302)
Annealed	60	(304)
Sheet and strip		
Cold-rolled, ¼ hard, *min.*	20	(302)
Annealed, *min.*	40	(302)
Sheet, annealed	60	(304)
Strip, annealed	50	(304)
Wire stock		
Up to ½-in. dia., annealed	50-60	
cold-drawn	10-35	
Bar stock		
½ to 2-in. dia., annealed	55	(303)
annealed	58	(302, 304)
cold-drawn	35	(303)
cold-drawn	40	(302, 304)
Over 2-in. dia., annealed	55	
Tubing		
Cold-drawn, half hard	10	(304)
Cold-drawn, full hard	5	(304)
Annealed	60	(304)

IZOD IMPACT

(*ft. lbs.*)

Plate—annealed	100	(304)
Bar stock		
Over ⅝-in. dia., annealed	70-80	(303)
annealed	110-115	(302, 304)
Tubing—annealed	100	(304)

MACHINE DESIGN is pleased to acknowledge the collaboration of the following in this presentation: Carpenter Steel Co.; Formed Steel Tube Inst.; Republic Steel Corp.; Rustless Iron & Steel Corp.; U. S. Steel Corp.; Westinghouse Electric & Mfg. Co.

Materials Work Sheet

CREEP STRENGTH (302,304)

(for life of 10,000 hrs. with 1% elongation)

TEMPERATURE	PSI
1000 deg. F.	17,000
1100	12,000
1300	4,000
1500	850

HARDNESS

ROCKWELL		
Plate		
Annealed	B80	(304)
Sheet and strip		
Cold-rolled, ¼ hard	C25	(302)
Annealed	B80	(302, 304)
Wire stock		
Up to ½-in. dia., annealed	B70-80	
cold-drawn	B90-100	
Tubing		
Cold-drawn, ½ hard	C30	(304)
Cold-drawn, full hard	C35	(304)
Annealed	B80	(304)
BRINELL (3000-kg. load, 10-mm. ball)		
Plate		
Annealed	150	(302, 304)
Bar stock		
Over ½-in. dia., annealed	160	
cold-drawn	220	
Tubing		
Cold-drawn, half hard	280	(304)
Cold-drawn, full hard	325	(304)
Annealed	150	(304)

REDUCTION OF AREA

(per cent)

Plate		
Annealed	73	(302)
Annealed	65	(304)
Bar stock		
Over ½-in. dia., annealed	55	(303)
annealed	70	(302, 304)
cold-drawn	50	(303)
cold-drawn	60	(302, 304)
Tubing		
Annealed	65	(304)

OTHER PHYSICAL PROPERTIES

Melting Point (deg. F.)	2550-2650
Temp. Coef. of Resistance (ohms per ohm per deg. C.) 0 to 100 deg. C.	.0011
Specific Gravity	7.9
Weight (lbs. per cu. in.)	.29
Modulus of Elasticity, annealed (psi)	28,000,000
Torsional Modulus of Elasticity Annealed (psi)	12,500,000
Coef. of Thermal Expansion (per deg. F.)	
0 to 200 deg. F.	.0000094
0 600	.0000095
0 1000	.0000101
0 1500	.0000111
Thermal Conductivity (g-cal/sq cm/sec/deg. C/cm)	
At 212 deg. F.	.039
932	.051
Electrical Conductivity (% of copper std.)	24
Electrical Resistivity Microhms per cu. in. at 70 deg. F.	28.4

PHYSICAL PROPERTIES AT ELEVATED TEMPERATURES

(short-time tests)

	Temperature (deg. F.)					
	800	1000	1200	1400	1600	1800
TENSILE STRENGTH (302,303,304)	67,500	62,000	46,000	31,500	19,000	10,000
ELONGATION IN 2 INCHES *(per cent)*						
Type 302	37	34	32	34	38	46
303	35	34	30	20	10	—
304	45	43	40	32	34	50
REDUCTION OF AREA *(per cent)*						
Type 302	70	68	63	52	54	70
303	52	54	54	44	42	—
304	68	68	62	50	43	48

BEND RADII FOR FLATS, SHEETS AND STRIPS

As a general "rule of thumb," the corner radius to be specified for a 90-deg. bend is equal to the thickness of the material. Where sharper corners are required, it is advisable to bend up sample pieces and determine by test the physical characteristics of the bend.

APPLICATION

AISI types 302 and 304 are extensively utilized in equipment for handling acetic, nitric and citric acid, and food and milk products; in valve trim, screws, bolts, aircraft wing covering, radiator grills, bearing plates, heat exchanger tubes, shafting, hydraulic tubing, piston rods and plungers, etc. Hard drawn wire is excellent for springs operating under adverse conditions.

AISI type 303, as its properties would suggest, is used for working parts in valves and pumps and in other applications requiring a freecutting, nongalling metal having high resistance to corrosion.

CHARACTERISTICS

AISI types 302 and 304 are, in normal times, the most widely used of the chromium-nickel stainless steels. These grades cannot be hardened by heat treatment. However, tensile strength and hardness may readily be increased by cold working. Combining high strength with substantial resistance to all ordinary corrosive agents, they possess excellent tensile properties at subzero temperatures and are normally nonmagnetic.

AISI type 303, with minor exceptions, is comparable in physical, tensile and corrosion-resisting properties to types 302 and 304. Normally this alloy is also nonmagnetic. By addition of sulphur or selenium, freecutting properties are

imparted to it. Where speed of machining is the most important factor, the sulphur-bearing composition is used. Where surface finish is the criterion, the selenium-bearing type is preferred. The nongalling, nonseizing characteristics of type 303 also are excellent.

SAFE INTERNAL WORKING PRESSURES OF TUBING

Apply formula:

$$P = 2S\frac{t}{d}$$

in which P = Internal working pressure (psi)
S = Working stress (psi)
t = Wall thickness (inches)
d = I. D. of tube (inches).

As the factor of safety used in determining S varies with types of application (for example, loading may be static or dynamic), no values for S are listed. Such values must be worked out in conjunction with "Physical Properties" data to fit specific applications.

FABRICATION

MACHINABILITY:

Because this material is extremely tough, its machinability does not equal that of bessemer screw stock. High-speed tools should be used at slow, constant speeds. For comparison, the relative speeds of the principal machining operations are shown in relation to those employed on the standard screw stock.

Operation	Type	Approx. Speed in Per Cent of Bessemer Screw Stock
Turning	302 & 304	60
	303	70
	303-Se	70
Forming and Drilling	302 & 304	40
	303	70
	303-Se	65

STAMPING, FORMING AND DRAWING:

Since these materials, even when dead soft annealed, are considerably stronger and harder than mild carbon steel, the press for stamping must have adequate power and be equipped with rugged, sharp tools made of the finest wear-resisting grades of tool steel. Gummy quality of the material gives it a tendency to gall or pick up on tools. Thus, blanking tools should have less clearance than for mild carbon steels since "break-out" property is poor. However, for deep drawing, the die clearance should be about twice that used for mild steel. Because it work-hardens nearly twice as fast as mild steel, it should be drawn and formed at slow press speeds and, if necessary, reannealed between draws. Scratching and galling can be effectively avoided by use of a suitable lubricant or drawing compound.

SPINNING:

Spinning is an extremely severe cold-working operation and will work-harden this material more quickly than will other methods of forming. Frequent reannealing therefore is required. In general, roller tools are more satisfactory than the solid nose types because they develop less friction.

FORGING:

Material is heated slowly to about 1500 deg. Fahr., then rapidly to 1900-2200 deg. Fahr., which is the proper forging

Materials Work Sheet

temperature. Being harder at elevated temperatures than mild steels, it requires more hammer blows. Forging characteristics approximate those of SAE 1040 and 3130.

WELDING:

Although stainless can be welded by acetylene torch, electric arc or resistance welding, metallurgical changes at high temperature may affect physical properties unless special techniques are employed. Follow steel producer's recommendations.

BRAZING:

Either welding or silver soldering, depending on type of application, are recommended instead of brazing. However, if brazing is done, it must be effected carefully to prevent the penetration of brazing alloy into the grain boundaries.

SOLDERING:

Solders without difficulty using ordinary solder and suitable flux. Because of low thermal conductivity, a large soldering iron is used to heat up the metal thoroughly. Acid remaining after soldering is washed off with a solution of washing soda.

RESISTANCE TO CORROSION

Are immune to most of the organic chemicals, sterilizing solutions, foodstuffs, dyestuffs, and a wide variety of inorganic chemicals. Resists nitric acid well, halogen acids poorly, and the sulphur acids moderately. To insure maximum corrosion resistance to prolonged outdoor exposure, parts are "passivated" or "immunized" by immersing them in a solution of nitric acid for 20 to 30 minutes, washing in water, and drying.

GALVANIC CORROSION

Aluminum, zinc, cadmium and ordinary iron or steel all tend to protect this material and the attack, if any, goes to the other metal. Nickel, lead, copper, brass, graphite and silver, however, reverse the attack and by so doing are themselves protected. It is understood, of course, that galvanic couple is established between dissimilar metals only when they are in contact in the presence of a liquid which is capable of carrying electric current. Sometimes an insulating lacquer is utilized to keep dissimilar metals apart.

ANNEALING

Heated rapidly to 1800-2100 deg. Fahr. and quenched in water. Materials are austenitic and will not harden with heat treatment. Generally supplied in the heat-treated (annealed) condition; reannealing is required only between bending or forming operations which work-harden the material.

DATA ON STOCK FORMS

(Sizes listed are those available in normal times)

Sheet Finishes

Hot rolled annealed and pickled
Bright cold rolled
Dull cold rolled
Standard polish on one or both sides
Standard polish and brushed
High luster polish
Mirror finish

Materials Work Sheet

Cold-Rolled Strip Finishes

Standard annealed and pickled
Standard annealed, pickled and re-rolled

Sheet Size Tolerances

Width

Up to 42 inches wide	1/16-inch plus, no minus
42 inches and wider	⅛-inch plus, no minus

Length

Up to 120 inches long	1/16-inch plus, no minus
120 inches and longer	⅛-inch plus, no minus

Note: .131-inch thick and greater, regardless of size, may have ¼-inch plus or minus in width and length.

Commercial Tolerances

Diam. or Across Flats (inches)	ROUNDS Tolerance (inches) Plus	Minus	Out of Round	SQUARES Tolerance (inches) Plus	Minus	Out of Square
3/16 or under	.005	.005	.008	.005	.005	.008
Over 3/16 to 7/16	.006	.006	.009	.006	.006	.009
Over 7/16 to ⅝	.007	.007	.010	.007	.007	.010
Over ⅝ to ⅞	.008	.008	.012	.008	.008	.012
Over ⅞ to 1	.009	.009	.013	.009	.009	.013
Over 1 to 1⅛	.010	.010	.015	.010	.010	.015
Over 1⅛ to 1¼	.011	.011	.016	.011	.011	.016
Over 1¼ to 1⅜	.012	.012	.018	.012	.012	.018
Over 1⅜ to 1½	.014	.014	.021	.014	.014	.021
Over 1½ to 2	.016	.016	.023	.016	.016	.023
Over 2 to 2½	.032	0	.023	.032	0	.023
Over 2½ to 3	.047	0	.035	.047	0	.035
Over 3 to 3½	.047	0	.035	....	....	....
Over 3½ to 4½	.062	0	.046	....	....	....
Over 4½ to 5½	.078	0	.058	....	....	....
Over 5½ to 6⅝	.093	0	.070	....	....	....

—HEXAGONS AND OCTAGONS—

Distance Across Flats (inches)	Tolerance Plus	Minus
Up to ½	.007	.007
Over ½ to 1	.010	.010
Over 1 to 1½	.021	.013
Over 1½ to 2	.032	.016
Over 2 to 2½	.040	.024

—ROUND CORNER SQUARES—

Distance Across Flats (inches)	Tolerance Plus	Minus
Up to 13/32	.007	.007
Over 13/32 to 1½	.014	.014
Over 1½ to 2	.016	.016
Over 2 to 2½	.032	0
Over 2½ to 3½	.047	0
Over 3½ to 4½	.062	0
Over 4½ to 5	.078	0

SQUARE EDGE FLATS

Width of Flat (inches)	Width Tolerance (inches) Plus	Minus	—Thickness Tolerance, Plus or Minus— (inches) Up to ⅜ thk.	Over ⅜ to ⅝ thk.	Over ⅝ to 1 thk.	Over 1 to 2 thk.	Over 2 thk.
Up to 1	.016	.016	.007	.010	.012	...	...
Over 1 to 2	.024	.024	.010	.012	.015	.020	...
Over 2 to 4	.032	.032	.010	.012	.015	.020	.031
Over 4 to 6	.062	.062	.010	.012	.015	.025	.031
Over 6 to 8	.078	.078	.012	.015	.020	.025	.031
Over 8 to 10	.093	.093	...	...	.020	.025	.031

ROUND EDGE FLATS

Width of Flat (inches)	Width Tolerance (inches) Plus	Minus	Thickness Tolerance, Plus or Minus (inches) Up to ⅜ thk.	Over ⅜ to ⅝ thk.	Over ⅝ to 1 thk.
Up to 1	.016	.016	.007	...	...
Over 2 to 2	.024	.024	.010	...	...
Over 2 to 4	.032	.032	.010	.012	...
Over 4 to 6	.062	.062	.010	.012	.015

MATERIAL DESIGNATIONS*

Army-Navy Aeronautical
(304) AN-QQ-S-771-G (bars, rods)
(303) AN-QQ-S-771-FM (bars, rods)

U. S. Air Corps
(304) 10079B (bars, rods, forgings)

Aeronautical Mat'l. Spec's.
(303) 5640A-Ty 1 (bars)
(304) Ty 2 (bars)

Federal
(303) QQ-S-763-Gr 7D (bars)

U. S. Navy
(302) 46S18 (INT)-1D (bars, rods)
(304) 46S18 (INT)-1A (bars, rods)

SAE
(302) 30915 (alloy steel)
(304) 30905 (alloy steel)

*Space does not permit listing all such designations. Those listed are typical.

Standard Sizes of Round Welded Stainless Steel Tubing

Wall Thickness (inches)	Outside Diameter—(inches) ⅜	7/16	½	9/16	⅝	11/16	¾	13/16	⅞	15/16	1	1 1/16	1⅛	1 3/16	1¼	1 5/16	1⅜	1 7/16	1½	1⅝	1¾	1⅞	2	2⅛	2¼	2⅜
.025	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	..	..	..	..	..
.028	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	..	..	..	..	..
.032	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	..	..	..	..	..
.035	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
.042	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
.049	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
.058	..	..	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
.065	..	..	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
.072	..	..	..	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
.083	..	..	..	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
.095	..	..	..	..	..	..	..	..	..	..	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
.109	..	..	..	..	..	..	..	..	..	..	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
.120	..	..	..	..	..	..	..	..	..	..	..	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

In addition: Tubing 2½, 2⅝, 2¾, 2⅞, and 3 inches O.D. available in wall thicknesses of .035 to .120 inclusive.
Tubing 3¼ and 3½ inches O.D. available in wall thicknesses of .042 to .120 inclusive.
Tubing 3¾, 4, 4¼, and 4½ inches O.D. available in wall thicknesses of .049 to .120 inclusive.

MATERIAL TRADENAMES

Type 302	Type 303	Type 304
Allegheny Metal 18-8	Allegheny Metal 18-8-EZ	Allegheny Metal 18-8-S
Armco 18-8		Armco 18-8
Bethadur 302	Bethalon 303	Bethadur 304
Carpenter No. 4	Carpenter No. 8	Carpenter 4-A
Rezistal KA2	Rezistal FM 188	Rezistal KA2S
Stainless "N"		Stainless "N"
Nirosta KA2	Nirosta FC	Nirosta KA2S
Hi-Gloss	Hi-Gloss FM	Hi-Gloss (No. 304) Spec.
Lesco 18-8	Lesco 18-8FM	Lesco 18-8S
Midvaloy 18-08	Midvaloy 18-08-Se	Midvaloy 18-08
Enduro 18-8	Enduro 18-8-FM	Enduro 18-8-S
Rustless 18-8	Rustless 18-8-FM	Rustless 18-8
Uniloy 18-8	Uniloy 18-8M	Uniloy 18-8S
USS 18-8	USS 18-8 FM	USS 18-8S

Producers

Allegheny Ludlum Stl. Corp.
American Rolling Mill Co.
Bethlehem Steel Co.
Carpenter Steel Co.
Crucible Stl. Co. of Amer.
Colonial Steel Co. & Vanadium Alloys Stl. Co.
Firth-Sterling Stl. Co.
Jessop Steel Co.
Latrobe Steel Co.
Midvale Steel Co.
Republic Steel Corp.
Rustless Iron & Stl. Corp.
Universal-Cyclops Stl. Corp.
U. S. Steel Corp.

Correction

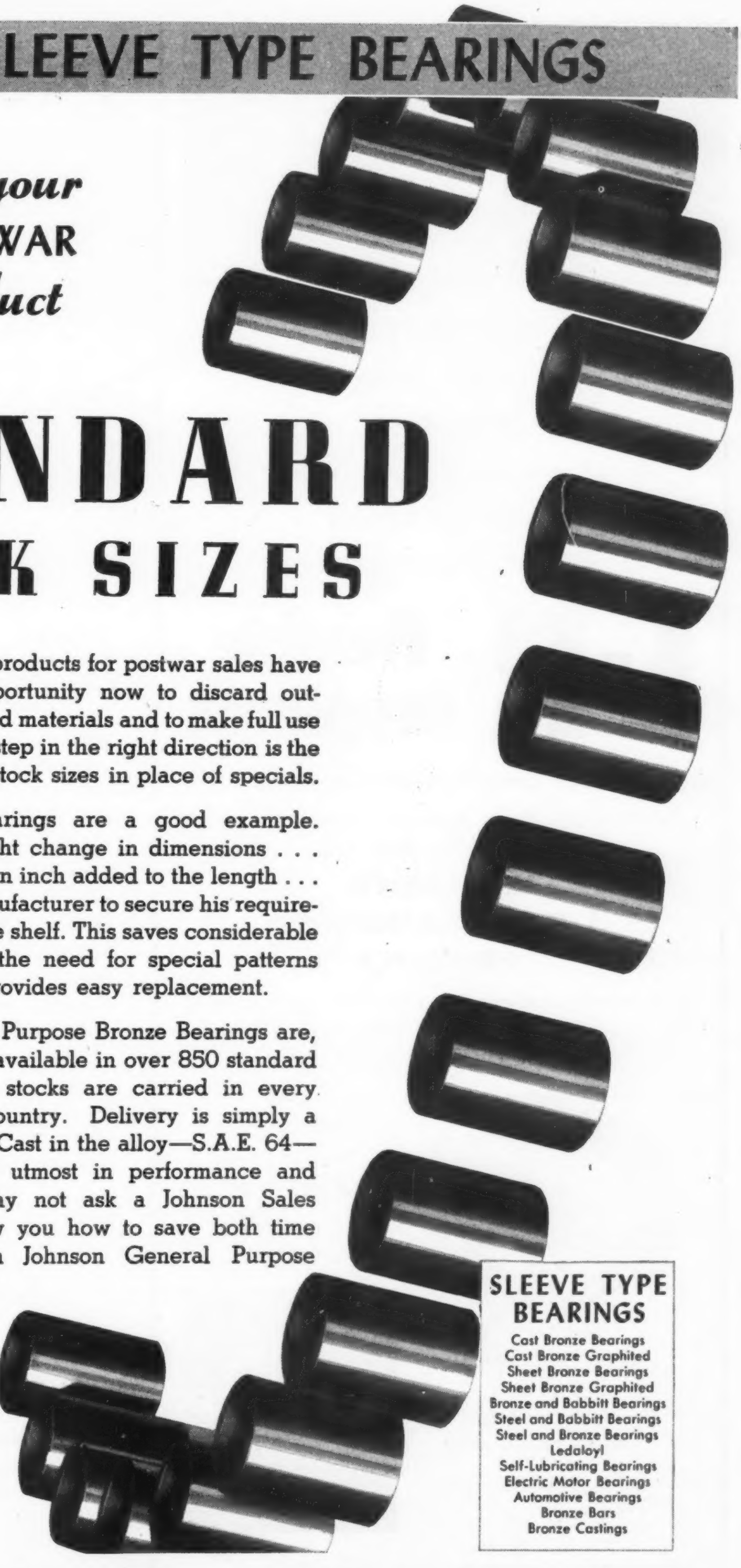
Formula appearing on second page of Materials Work Sheet for aluminum alloy 24S-T (see October issue) should read:

$$P=S\frac{D^2-d^2}{D^2+d^2}$$

JOHNSON BRONZE

SLEEVE TYPE BEARINGS

For your
POSTWAR
Product



STANDARD
STOCK SIZES

● Designers of products for postwar sales have an excellent opportunity now to discard outdated methods and materials and to make full use of new ideas. A step in the right direction is the use of standard stock sizes in place of specials.

Sleeve type bearings are a good example. Very often a slight change in dimensions . . . perhaps 1-32 of an inch added to the length . . . will enable a manufacturer to secure his requirements right off the shelf. This saves considerable time, eliminates the need for special patterns and tools, and provides easy replacement.

Johnson General Purpose Bronze Bearings are, in normal times, available in over 850 standard sizes. Complete stocks are carried in every section of the country. Delivery is simply a matter of hours. Cast in the alloy—S.A.E. 64—they deliver the utmost in performance and bearing life. Why not ask a Johnson Sales Engineer to show you how to save both time and money with Johnson General Purpose Bronze Bearings?

Specify . . .
**JOHNSON
GENERAL PURPOSE
BEARINGS**

SLEEVE TYPE BEARINGS

Cast Bronze Bearings
Cast Bronze Graphited
Sheet Bronze Bearings
Sheet Bronze Graphited
Bronze and Babbitt Bearings
Steel and Babbitt Bearings
Steel and Bronze Bearings
Ledaloyl
Self-Lubricating Bearings
Electric Motor Bearings
Automotive Bearings
Bronze Bars
Bronze Castings

JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS
The MOST COMPLETE SLEEVE BEARING SERVICE *in the* WORLD
525 S. MILL STREET NEW CASTLE, PA.

PROFESSIONAL VIEWPOINTS

". . . originated in U. S."

To the Editor:

We were glad to see Dr. Wahl's article "Designing Ring Springs" in your August issue. With respect to the usefulness of a spring of this type, it may be of interest to note that even before the present war the Germans had made up at least 40 different designs of ring springs for airplane landing gears.

The use of the ring spring in airplane landing gears originated in the United States, where the first patent on this application was issued. The Germans were, however, the first to test ring-spring landing gears in actual combat (presumably during the Spanish civil war), and the result was so gratifying that it was adopted by the German army and navy as standard equipment. In the United States the ring-spring landing gear has, however, not as yet replaced the older types to any extent.

An important use of the ring spring is in railway draft gears, and official tests by the American Association of Railroads illustrate their superior performance in this application. Their actual service record is equally outstanding. Ring-spring-equipped couplers for electric railways, as well as for military trucks, are used to a steadily increasing extent.

An important and widening field of ring-spring application is in adapters for various types of guns—particularly guns for use in airplanes. Vibration isolation is another growing field, where the ring spring is used to supplant or assist rubber pads and coil springs.

The number of ring-spring applications is steadily increasing, as engineers become more familiar with their character and realize that this new machine element offers a practical solution to many baffling problems.

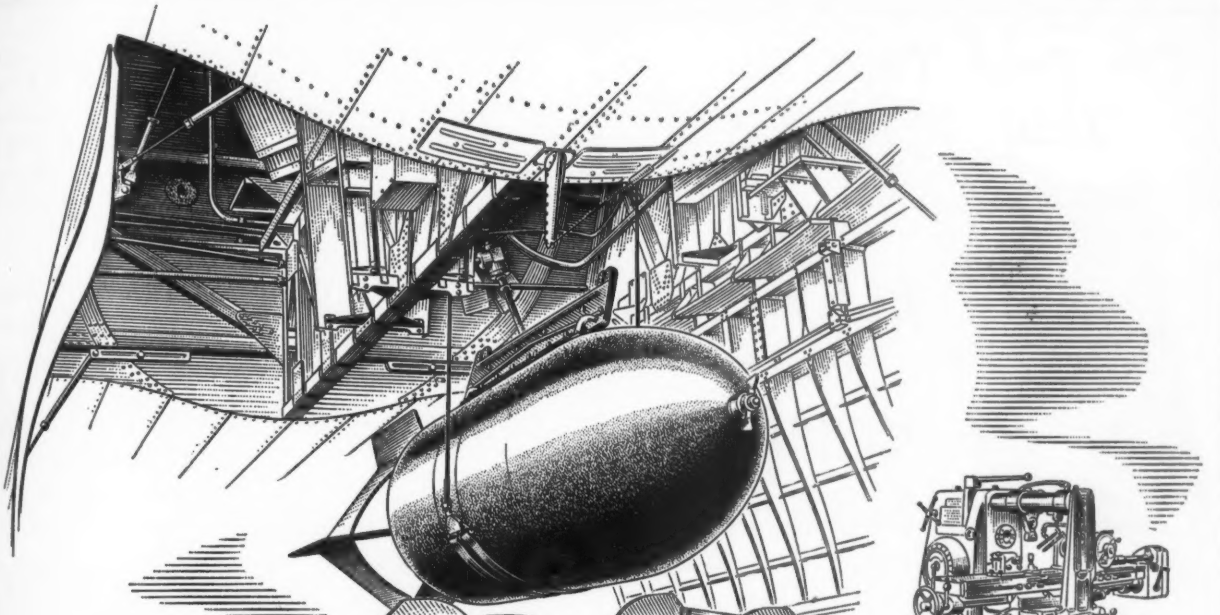
—O. R. Wikander
Edgewater Steel Co.

". . . simplifies chart reading"

To the Editor:

To simplify and speed calculations with nomograms, or alignment charts, a nomogram reader as shown in the accompanying illustration is particularly helpful. The reader may be produced inexpensively by using 3/32-inch Plexiglas and, in its simplest form, has a single transparent pivot with cross hairs as shown. It may also have a sliding pivot if needed.

The usual method of reading such a nomogram is to place a ruler against the known value of the first variable, rotate it until it crosses the known value of the second variable, and read the desired answer where the ruler crosses the third scale. However, in lining up the ruler with the second scale setting, it generally becomes dis-



The Bomb Hoist was "*Struck*" by Something in the Milling Machine

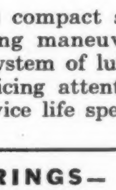
It may be news to some that a part so long at home in milling machines proved equally effective in bomb ammunition hoists. For the milling machine is a precision tool in which ease and speed of operation are vital. Noted for its anti-friction operation, the Torrington Needle Bearing is used in some of the most famous of these tools to meet just such milling machine "musts" on various hand and power-operated trip levers.

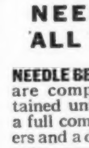
With the bomb ammunition hoist ease of operation is, of course, important, too. But of even greater concern in these days of mightier and mightier "blockbusters" is the danger of overloading. Where bomb hoists do their work, "spares" and often adequate repair facilities may be painfully conspicuous by their absence. That's why the Needle Bearing scored a "direct hit" with the designers of bomb hoists—its high unit capacity helps prevent overloading or breakdowns, and low coefficient gives it a "made-to-order" operating ease.

The pay-off, however, is that this unique anti-friction bearing had several *other* features which helped build a better bomb hoist—its compact size saves weight, increasing maneuverability...its effective system of lubrication means less servicing attention required...its long service life speaks for itself...while the ready availability of the Needle Bearing eliminated one of the most frequent obstacles in war production—delay in delivery.

NEEDLE BEARINGS—ALL TYPES—ALL SIZES

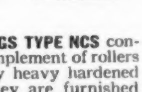
NEEDLE BEARINGS TYPE DC are complete, self-contained units consisting of a full complement of rollers and a drawn, hardened outer race. They offer the advantages of small size, low cost, high capacity—and easy installation.





NEEDLE BEARINGS TYPE NCS consist of a full complement of rollers and a relatively heavy hardened outer race. They are furnished with or without inner races. Needle Bearings Type NCS are adaptable to heavier loads than Needle Bearings Type DC.

NEEDLE ROLLERS TYPE LN are produced in a range of types and sizes for assembly on the job into low-cost, high-capacity, anti-friction bearing units. Our engineering department will be glad to advise on the correct size and type for any application.



ISN'T THIS SOMETHING TO THINK ABOUT in planning your postwar designs? Not alone because of the Needle Bearing's adaptability to a wide variety of products for entirely different reasons, but also because its unique combination of advantages represent the very features customers will be looking for Tomorrow in the things for peacetime living—light weight, compactness, ease of operation, freedom from maintenance and long life. Torrington engineers are ready to point out how you can give your product these same advantages with the Needle Bearing. For preliminary information on sizes, types and ratings, together with a list of typical applications, send today for Catalog No. 109.

THE TORRINGTON COMPANY

Established 1866 • Torrington, Conn. • South Bend 21, Ind.

Makers of Needle Bearings and Needle Bearing Rollers

New York · Boston · Philadelphia
Detroit · Cleveland · Seattle
San Francisco · Chicago · Los Angeles
Toronto · London, England

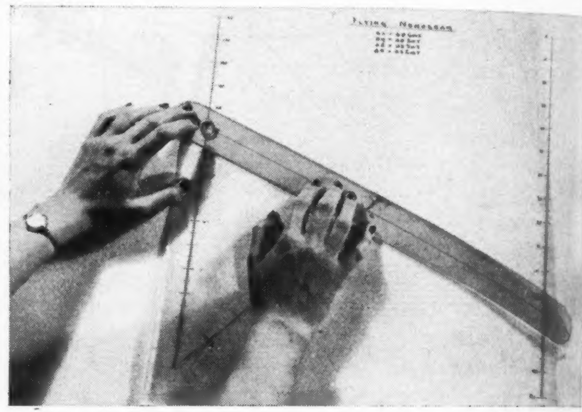
LET'S GO U.S.A. KEEP 'EM FLYING!

TORRINGTON NEEDLE BEARINGS

placed from the first one, so that several adjustments are required before an accurate reading can be taken.

For use with this type of nomogram, the reader has only one pivot. The cross hairs of the pivot are set on the known value of the first variable and a finger placed firmly on the pivot. The rule may then be rotated freely until its index line lies on the known value of the second variable without any chance of the rule's becoming displaced from its first setting. The answer is read where the index line crosses the third scale.

The transparent pivot makes it possible to locate accurately the first setting and maintain it while making the



second. The index line permits more accurate reading and interpolation than does a ruler, because there is no obstacle to vision. Parallax is eliminated by having the index line etched on the lower surface of the Plexiglas.

Use of Plastacele for nomograms instead of graph paper may be of interest to designers and users of nomograms. It is undistorted by humidity, withstands hard usage, and does not mark or soil easily. If soiled, it can be cleaned with a moist cloth. To prevent abrasion of the scales they are inked on the reverse side. To facilitate laying the scales out in pencil and inking them, sheets with one frosted side are used. Equations with more than two known variables require for their solutions the use of "multiple" nomograms, necessitating several settings of the rule and often the marking of a point on a blank scale. For such cases, a reader with a second pivot which slides in a slot is particularly helpful for holding a point on the "turning scale".

It has been found through actual use for thousands of calculations in our mathematics department that a reader aids materially in obtaining speed and accuracy in calculation.

—Clifford M. Mast
The Jam Handy Organization

SHIPPING AND STORING fuel all over the world without its quickly forming gum which would clog motors and fuel lines of planes, tanks and trucks is accomplished by adding less than one-half ounce of a chemical gum inhibitor per hundred gallons of gasoline. Addition of a fraction of a per cent of tetraethyl lead to refined gasoline raises its rating to that of 100-octane fuel.

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Sheet...Strip...Rod...Tubing...Wire...Castings

Data on 108 Metals and Alloys

Monel (wrought and cast)
"R" Monel, "K" Monel
"H" Monel, "S" Monel
Nickel (pure, wrought and cast)
"D" Nickel, "Z" Nickel
Inconel (wrought and cast)
Hastelloy A, B, C, D
Illium G, R
Alcoa 2S, 3S, 17S, 52S, 53S
Alclad 24S
Alcoa 13, 43, 195, 214, 220
Copper
Red Brass (wrought and cast)
Yellow Brass (high brass)
Naval Brass (Tobin bronze)
Admiralty Brass
Muntz Metal
Manganese Bronze
Silicon Bronze
Phosphor Bronze 5%
Aluminum Bronze
Beryllium Copper
Nickel Bronze (cast)
Nickel Silver 20% (cast)
Nickel Silver 18% (wrought), 13% (cast), 10% (wrought)
Ambrac 20%
Cupro-Nickel 70-30, 55-45
Tin
Chemical Lead
Antimonial Lead
Tellurium Lead
Soft Solder 50-50, 60-40
Zinc
Zilloy 15, 40
Dow Metal E, H, R, X
Silver (pure)
R-T Silver Brazing Alloy
Easy-Flo Silver Brazing Alloy
Gold (pure)
Platinum (pure and commercial)
Iridium-Platinum 10%
Rhodium-Platinum 10%
Palladium (commercial and hard)
Tantalum
Iron (wrought, ingot and cast)
Ni-Tensyliron
Ni-Resist (standard and copper-free)
Ni-Hard, low carbon, high carbon
Carbon Steel (SAE 1020)
Cast Carbon Steel
Cast Alloy Steel
Stainless Steel 304, 309, 310, 316, 321, 347, 325, 410, 420, 430, 446, 312, 330
Cast 18 Cr 8 Ni Steel
Cast 18 Cr 8 Ni 3 Mo. Steel
Invar
Cast 28 Cr 10 Ni Alloy
Cast 35 Ni 15 Cr Alloy
60 Ni 15 Cr Alloy (wrought and cast)
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Iron Silicon Alloy
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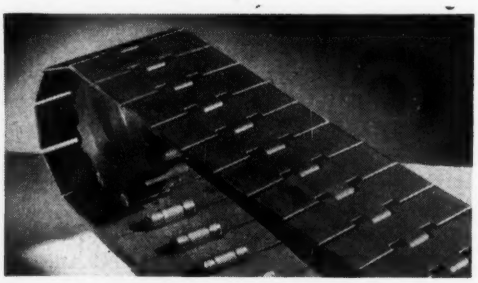
New PARTS AND MATERIALS

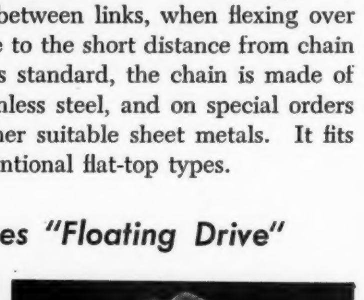
Flat-Top Chain Belt Improved

DESIGNATED as REX S-815, an improved flat-top chain belt for conveyor service in the food packing and bottling industries, offered by Chain Belt Co., 1604 West Bruce street, Milwaukee, embodies unique features in construction. A more accurate pitch, smoother operation, higher resistance to corrosion, and better appearance are some of the features. The links of the new belt are blanked and formed from finished strip steel and assembled with pins which are upset at each end. The one-piece link and pin are the only parts; the flight is integral with the link and there are no attachment rivets



to work loose. Top edges of the links are beveled to allow transfer of containers from one link to another without tipping. Links may be removed by driving out pin. No special coupler links are necessary since all links are identical, and the chain strand can be altered by only one pitch length. Gap between links, when flexing over the sprocket, is small due to the short distance from chain top to center of pin. As standard, the chain is made of both plain steel and stainless steel, and on special orders can be blanked from other suitable sheet metals. It fits the same tracks as conventional flat-top types.

Motor Features "Floating Drive"



AN ANSWER to shock-load problems, stepless speed variation needs and other rotary power requirements is the new HydrOILic fluid motor announced by Denison Engineering Co., Columbus, O. It features a "floating drive" which eliminates mechanically linked or universal type drive rods, ending distortion or breakage from sudden starts, stops or reversals. At the same time a displacement motor, it delivers rotating power in either direction at any speed. Direct pressure and constant contact between driving and driven elements prevents backlash or take-up motion. Horsepower output of the motor is proportional to its revolutions per minute with a given operating pressure of the fluid. Actual running torque is estimated at 95 per cent of theoretical torque, and stalled torque is 85 per cent of running torque. The motor can be adapted to horizontal, vertical or angular mounting. Faceplate, footplate or flange type mounting plates are available and the mounting position of the motor has no effect on its operation. Because of the axial piston design, the motor has no set center position from which manual help is required in starting it.

25-Ampere Aircraft Contactor

THROUGH its Industrial Controller division, The Square D Co., 4041 North Richards street, Milwaukee 12, has announced a 25-ampere, Type B2A aircraft contactor manufactured to meet Army Air Forces specification No. 94-32185D. The new contactor is now available in the Class 9350 aircraft contactor line which previously included 50, 100 and 200 ampere sizes. B2A contactors may be used for remote control, starting and stopping of direct-current motors, or as relays in gun fire, lighting, or communication circuits. Performance under severe flight conditions is assured by the simple design and heavy-duty contact capacity. The contactors weigh 7 ounces and are rated 25 amperes continuous duty for potentials up to 29 volts direct current. They will operate under acceleration forces up to 10g or vibration conditions as severe as 55 cycles per second at 1/16-inch excursion and are suitable for a temperature range of —65 to 160 degrees Fahr.

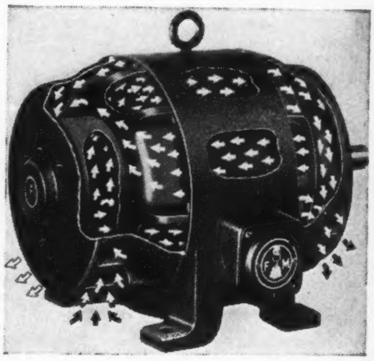
Tin-Base Babbitt Substitute

IN ADDITION to its present line, National Bearing Metals Corp., St. Louis, is offering a silver babbitt, an outgrowth of the shortage of tin. As a result of research

by Battelle Memorial institute to find a babbitt metal comparable to the tin-base babbitts, silver alloyed with a properly balanced lead-base babbitt was found to have the same bondability and corrosion resistance as that of tin-base babbitts. The new material will retain its hardness at operating temperatures without squeezing out.

All-Purpose Induction Motor

EMBODYING many special features, a new type, all-purpose, continuous-duty, polyphase squirrel-cage induction motor has been made available by Fairbanks, Morse & Co., 600 South Michigan avenue, Chicago, for use in all kinds of industries. Constructed with a centrifugally cast, copper-spun rotor, the new motor is fully protected against flying chips, falling particles, dripping liquids and other industrial motor hazards. Ball bearings are sealed in cartridge-type housings. Cross-flow ventilation, a feature in frames 224 to 365 inclusive, is

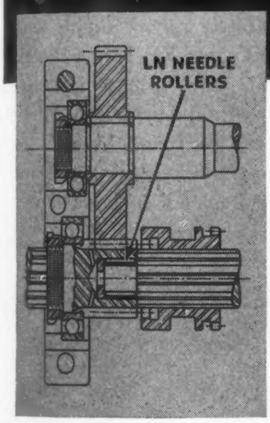


obtained through protected inlets and exhausts at each end of the motor, resulting in uniform cooling and elimination of hot spots. Frame is cast with rib sections for strength without increased weight. Where space is limited, conduit can be brought up between the motor feet to the tapped hole in the motor frame and conduit box cover assembled flush with the frame. External box is then discarded. When the conventional conduit box is used the motor can be mounted in any of four positions. It is rated 40 degrees Cent. and is designed to carry 115 per cent load continuously without injurious heating (1.15 per cent service factor).

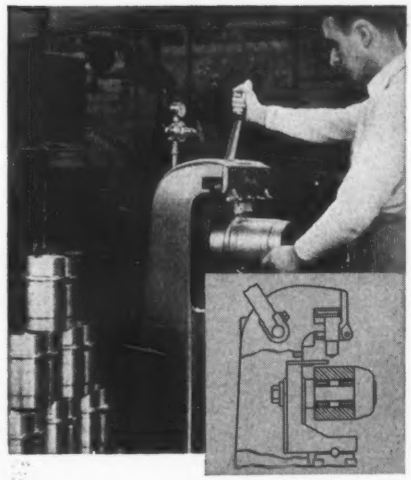
New Synthetic Plastics

TO THE synthetic plastics a new group of coal-limestone-and-air derivatives have been added which, according to Resistoflex Corp., Belleville, N. J., might be termed the missing link between plastics and synthetic rubber. Known as "Compars", derived from the words "compounded polyvinyl alcohol resins," numerous variations have been developed out of the demand by warplane designers for a flexible material to handle toluol, xylol and benzol. The compars are described as transparent, flexible, rubber-like plastic materials, five to twenty times more wear resistant than natural rubber, and

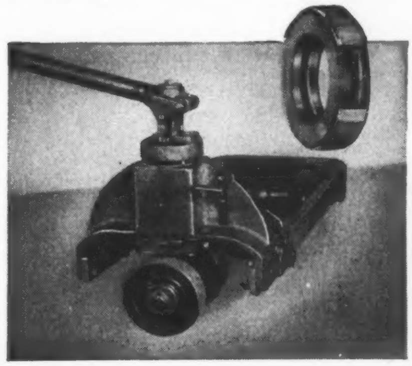
IN THE NEWS
WITH TORRINGTON—BANTAM



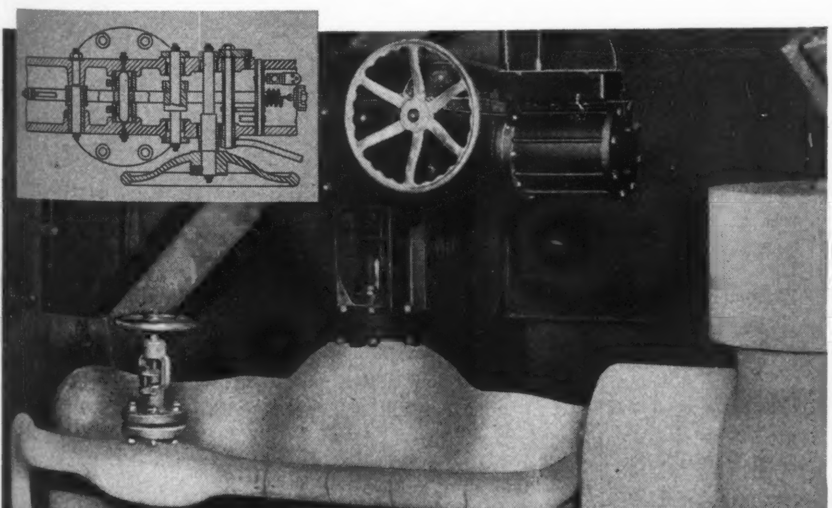
MACHINING GIANT CASTINGS to precision limits is simplified by this 6-inch spindle, floor-type horizontal boring, drilling and milling machine manufactured by The Ohio Machine Tool Company. 44 Type LN Needle Rollers, which are used as the pilot bearing of the transmission, as shown in the accompanying cross-section, contribute materially to the smooth, stable and precise performance of these finely engineered milling machines. Needle Bearings in all types and sizes from one-quarter inch to over seven inches in diameter for virtually all needs are available from Torrington. Our engineers will be glad to help in the selection of the type to meet your requirements.



MARKING ROUND OR FLAT SURFACES, precision graduating and serial numbering are the accomplishments of this versatile Pneumatic General Purpose Marking Machine built by the Noble and Westbrook Manufacturing Company. The worker shown here is marking part numbers on finished aircraft engine cylinder barrels, while the cross-section shows the mandrel support which holds the work. A compact, high capacity Type NCS Needle Bearing carries the mandrel to provide ease of rotation.



MATERIALS HANDLING with manual equipment is aided by such modern items as this liftruck manufactured by the Revolvator Company. Unusual maneuverability is made possible by the free 360° swing of pump and pulling handle, which is designed for anti-friction operation through use of a Torrington Ball Thrust Bearing in combination with a Type DC Needle Bearing.



WATER FLOWING AT HALF-TON PRESSURES through an 8-inch pipe is controlled by this three element feed water control valve made by the Bailey Meter Company. The valve is part of the control system of a modern high pressure boiler which serves a 60,000 kwh turbine in an electric generating plant. As shown in the accompanying cross-section, Type NCS Needle Bearings assure dependability and ease of operation for which this valve is noted. Further information on Needle Bearings is available on request.

IF YOUR NEED IS FOR LARGE BEARINGS, Torrington-Bantam's experience in the design, application and manufacture of outsize bearings is of special value. Or if you have a bearing problem which appears to call for special treatment, the experience of Torrington engineers in the design and application of every major type of anti-friction bearing suggests that you can profitably TURN TO TORRINGTON for expert counsel.

ARMY (E) NAVY

TORRINGTON BEARINGS

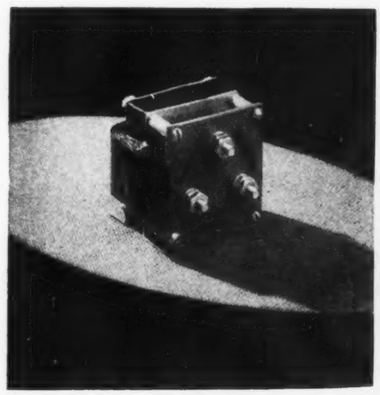
STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION
SOUTH BEND 21, INDIANA

the most solventproof rubber-substitute developed. Some already are in use in warplane fuel and hydraulic hose, naval diesel engines, chemical warfare equipment, etc., while other war uses are said to be in the development stage and postwar uses are expected. Some characteristics of this group are: Flexibility; toughness; abrasion resistance; chemically unaffected by organic solvents such as aliphatic and aromatic hydrocarbons, chlorinated hydrocarbons, ketones, etc.; low permeability to industrial, refrigerant and military gases; high tensile strength; and freedom from aging or oxidation. Some varieties of these materials will remain flexible at temperatures as low as —70 degrees Fahr. or as high as 300, and some are insoluble in water at all temperatures with swelling limited to 10 per cent and the water absorption to about 15 per cent.

Two and Three-Phase Transformers

FOR use with aircraft gyro instruments General Electric Co., Schenectady, N. Y., is offering its two-phase transformer. This provides correct power supply for the operation of the company's Types KB-1 (gyro-horizon) and KC-1 (directional gyro), three-phase instruments equipped with a 750 volt-ampere inverter. A 115-volt, three-phase, 400-cycle output is supplied from the dual 26-volt and 115-volt output provided by the inverter. Measuring approximately 2⅝ x 2½ x 2¾ inches and weigh-



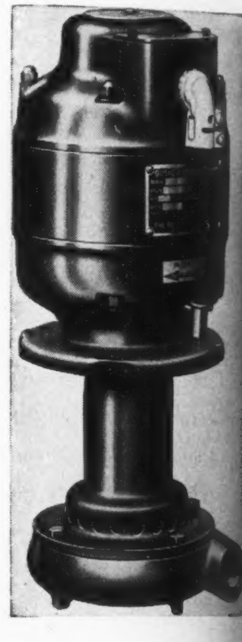
ing 13.6 ounces, the transformer will operate one or any combination of two of the above instruments, bringing them up to full speed in about 1¼ minutes at normal temperature (25 degrees Cent.). It will operate efficiently at any altitude when suitable ventilation is provided, and meets the United States Army Air forces requirements.

Decals for Crinkle Finishes

TWO new marproof and wear-resistant decalcomania nameplates have been designed by The Meyercord Co., 5323 West Lake street, Chicago 44, for speedy, permanent application on raw, painted or crinkle-finished metal. Known as Type C and Type G, now only available for war uses, the new transfers result in a saving of time, money, weight and critical nameplate metals, as well as eliminating rivets, bolts and screws. The decals are usable on flat, convex or concave surfaces and have

been subjected to rigid tests for abrasion, extremes of heat and cold, immersion, salt spray and humidity. They are available in a wide range of colors in either the Type C open-letter design or the Type G background transfer design.

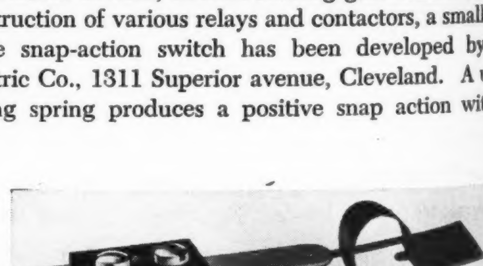
Motor-Driven Gusher Pump



RECENTLY developed by The Ruthman Machinery Co., Cincinnati, the new immersed type motor-driven gusher pump is equipped with integral flange bracket for reservoir cover or bedplate mounting. Known as Model No. 9040, it is designed for interchangeable installation with gusher model 1-P3 pump, and is available in any current characteristics including 25 cycle; one, two or three-phase. The ¼-horsepower operating motor is ball bearing equipped, totally enclosed, with one-piece rigid shaft which extends to the pump impeller. Made in two lengths, dimensions from the mounting flange to the bottom of the pump are 6 7/16 and 8 7/16 inches respectively. It can be had with either ½ or ¾-inch pipe size discharge.

Open-Blade Snap-Action Switch

FOR a variety of applications including machine tool control devices, aircraft landing gear controls, and for construction of various relays and contactors, a small open-blade snap-action switch has been developed by Acro Electric Co., 1311 Superior avenue, Cleveland. A unique rolling spring produces a positive snap action with less



than 6 ounces operating pressure. As a result smaller coils may be used in relays incorporating this switch. Design and operation of the spring switch minimize contact burning because of its fast action. The switch also permits both pretravel and overtravel. Rating is 15 amperes on 125 volts alternating current. Overall size is 3 3/16 x 11/16 x 1/2 inches. Made in single-pole, single

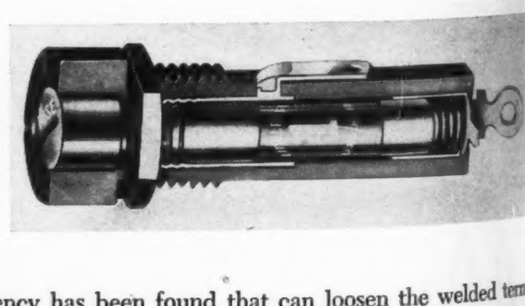
or double-throw, set and return types, it also is assembled to meet the needs of relay builders.

Mercury Plunger Relay

NORMALLY closed, mercury-plunger relay is being furnished by H-B Electric Co., 6111 North Twenty-first street, Philadelphia, for emergency lighting or any application where a normally closed relay is required. Having one moving part, high-speed silent operation, and no exposed arc makes the relay acceptable for isolated locations. It is gravity-operated and eliminates use of springs as an actuating medium. Plunger is designed to displace sufficient mercury to flood contacts which consist of two pools of mercury. When coil is energized the plunger is lifted and the mercury recedes, permitting the flooded pools of mercury to separate into two pools of mercury and thus opening the circuit. The mercury-to-mercury make and break is ideally suited for high inrush and inductive circuits. Relays can be furnished with coils for any operating voltage and load ratings up to 4.5 KVA. A variety of housings and mountings is available for individual requirements.

Extractor Post Terminal Welded

EXTRACTOR post for 3 AG (1¼ x ¼-inch dia.) fuses, announced by Littlefuse Inc., 4747 Ravenswood avenue, Chicago 40, has terminals connected by welding, thus making the unit vibrationproof. Side terminals are welded to the metal shell inside the bakelite body and are backed up by soft solder. It is claimed by the company that in actual service as well as in laboratory tests, no emer-

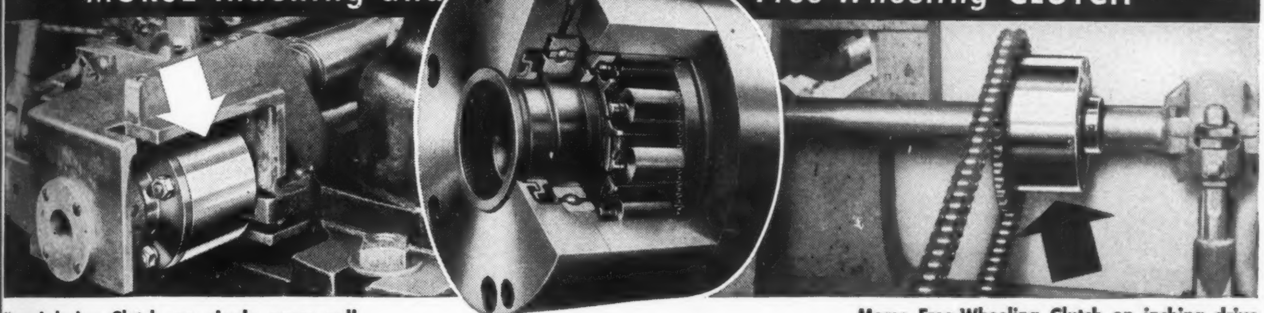


gency has been found that can loosen the welded terminals. Extractor post No. 1075 for fuses to 15 amperes is used for radios, auto-radios, amplifiers, fractional-horsepower motors, magnets, control circuits, relays, rectifiers, plate circuits, etc. Overall length is 2½ inches; length from front to panel, 2⅛ inches; mounting hole, ½-inch. Maximum current is 15 amperes. Knob and body are molded black bakelite, impervious to temperature changes and corrosion, and thoroughly insulated. Spacing be-

MORSE CLUTCHES
Meet Many Needs

High quality functional clutches designed in a wide range of sizes and capacities for indexing, free-wheeling and backstop service.

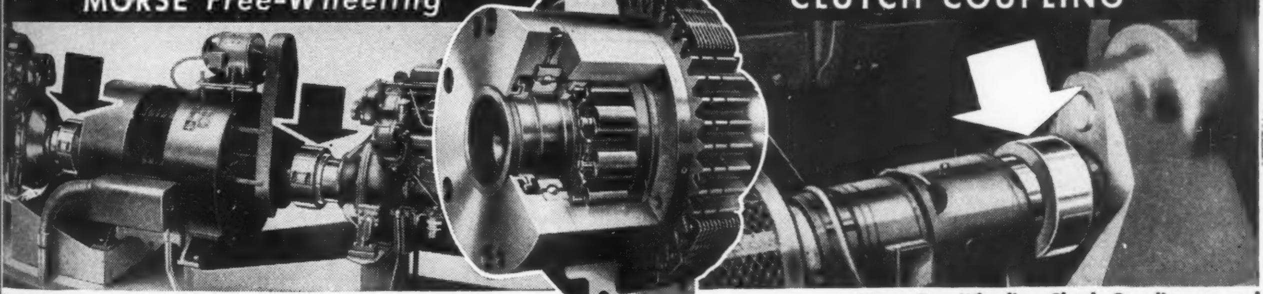
MORSE *Indexing and Free-Wheeling* CLUTCH



Morse Indexing Clutch on single press roll feed to press.

Morse Free-Wheeling Clutch on inching drive on paper process machine.

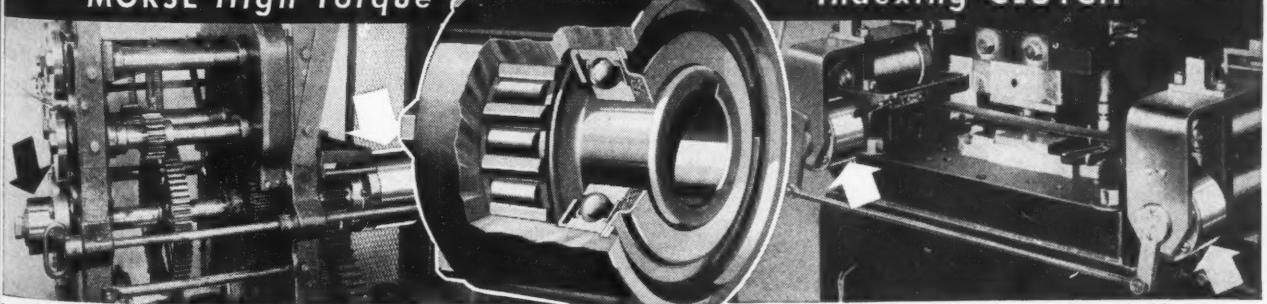
MORSE *Free-Wheeling* CLUTCH COUPLING



Morse Free-Wheeling Clutch Couplings on dual driven, direct connected generator.

Morse Free-Wheeling Clutch Coupling on reel unwinder drive in steel mill.

MORSE *High Torque Indexing* CLUTCH



Two Indexing Clutches on segment type universal spring coiler . . . one for feeding wire, the other for backstop.

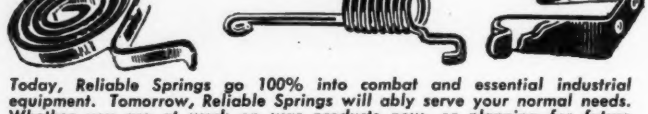
Morse Indexing Clutch on double press roll feed.

Morse precision products also include silent and roller chain drives, sprockets, chain couplings, Morflex Couplings, Radial Couplings, Pullmore clutches, automotive time chains and marine drives.

SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS CLUTCHES

MORSE *positive* DRIVES

MORSE CHAIN COMPANY ITHACA, N. Y. DETROIT, MICH. DIVISION BORG-WARNER CORP.



tween live parts provides adequate protection against electrical leakage. Fuse grip permits full visual shock-proof inspection of fuse. A spring-activated cup at the bottom insures both positive and continuous electrical contact.

Solenoid-Operated Fluid Valve

DESIGNED for remote control of anti-icing fluid flow to the various critical parts of the airplane that are subject to ice accumulations, a new solenoid-operated fluid shut-off valve introduced by Adel Precision Products Corp., 10777 Vanowen avenue, Burbank, Calif., weighs only 6.96 ounces. Having a dural body, the valve is equipped with standard AN 3102-8S-1P receptacle and may be had in port sizes for ⅛-inch pipe thread or ¼-inch tube fittings. Valve is normally closed. Installation may be planned for any operating position. Current is .25 amperes, 24 volts direct current. Units are available for working pressures of 50 and 250 pounds per square inch. In addition to its use in the ice protection of propellers, pilots' windshields, bombardiers' windows, carburetors, and pitot tubes, it is adaptable for a number of other systems such as heater fuel or oil dilution control, etc.

Foot-Operated Switch

TO FACILITATE starting and stopping of any electrical machine or equipment operated by foot pressure, Metallic Arts Co., 243 Broadway, Cambridge, Mass., has announced its Maco foot switch. It is rated at 125 volts at 15 amperes alternating current. Spring tension on pedal is flexible, allowing either light or heavy pressure. Housing is gray-iron casting with wrinkle finish in machine tool gray; it fits closely to prevent chips and oil from reaching electrical components inside. Overall dimensions are 6½ x 3¾ x 2½ inches. Electrical connections can be made to screws of approved barrier strip, thereby eliminating use of soldering iron.

Aircraft Selector Switch

INCORPORATING snap action, a new type of aircraft selector switch has recently been perfected by The Paul Henry Co., Los Angeles. Known as a cam-snap rotary tap switch, it is made with from one to four primary circuits and twelve secondary circuits, permitting a variety of applications such as pilot compartment heater control, wing flap control, cowl flap control, and others where a sequence of operation is desired. Opening and closing of a circuit is accomplished within three or four degrees motion of the cam. Current rating for 50,000 operations

WHERE does Stackpole Molded Powder Metallurgy Fit into YOUR Picture?

... it pays to know!

"EVERYTHING IN CARBON BUT DIAMONDS"

Brushes for all rotating machines—Anodes—Electrodes—Brazing Blocks—Bearings—Welding Rods, Electrodes and Plates—Pipe—Packing Piston and Seal Rings—Rheostat Plates and Discs—Brake Lining, etc.

MOLDED METAL CONTACTS

...also Fixed and Variable Resistors, Iron Cores, and Switches for the Electronics Industry

Iron powders made from non-critical mill scale and ore, solidly molded to close tolerances represent an important source of easier-to-obtain and less costly components for a wide variety of products.

From molded gears, to pole pieces for small motors, magnetic yokes for circuit breakers, and iron cores, to large parts and unusual shapes where much machining is ordinarily involved, Stackpole Molded Powder Metallurgy is already outstandingly effective in many industries—and this is barely the beginning.

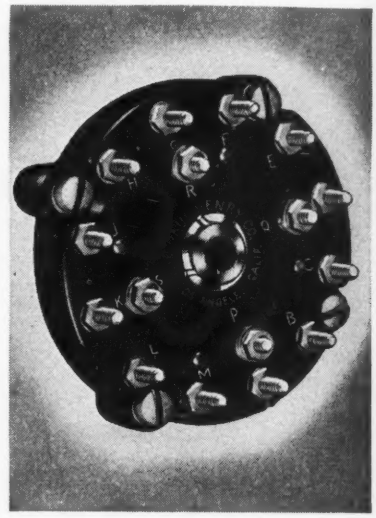
So far-reaching are the possibilities of these molded materials, it is safe to say that there are few products indeed wherein the possible use of such components should not be considered. Stackpole engineers welcome the opportunity to cooperate—and to tell you frankly whether or not Stackpole Powder Metallurgy methods may be of service.

STACKPOLE CARBON COMPANY, ST. MARYS, PENNA.

STACKPOLE

MOLDED CARBON AND METAL PRODUCTS

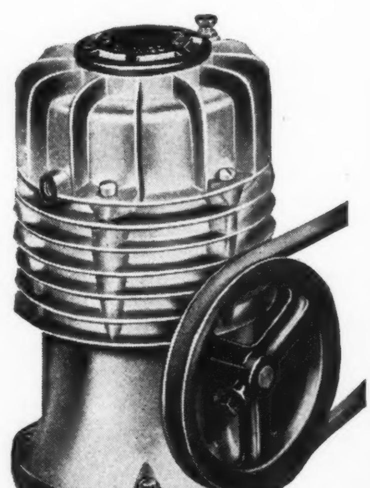
is 10 amperes at 29 volts, inductive load. Used as a selector switch, it may be mounted singly or in gang and operated by a single shaft. Shaft is serrated but can be furnished either in hex or square design. Any type of cam-operating member can be incorporated. All circuits



have screw terminals requiring no soldering. The unit is extremely light in weight (three to four ounces) and fits any standard instrument mounting. Case is fully enclosed and is built of macerated phenolic.

Air Compressor Improved

SMALL but powerful air compressor has been developed recently by W. R. Brown Corp., 5720 Armitage avenue, Chicago 39, to meet United States Navy standards of compactness, lightness and efficiency. Available

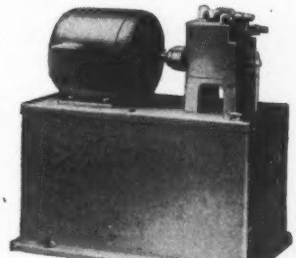


for installation on equipment and machinery requiring compression or vacuum, the compressor delivers two cubic feet free air per minute at pressures up to 45 pounds. Vacuum up to 25 inches is produced. A feature of the new unit is the elimination of heavy, oily pistons and rings, employing instead multiple-ply diaphragms which

Be prepared to meet post-war markets, by thinking ahead and installing "Airgrip" Holding Devices. When peace comes these versatile "Airgrip" Devices will speed up the change over to consumer market requirements—lower unit costs, more manufactured items in a shorter time at prices that will attract the buying public. Put to work now, they will step up war output more than 25%. Simple and easy to operate, by either men or women, they also help solve the labor shortage.

"Airgrip" Holding Devices are available on short notice, and they can be quickly installed. "Airgrip" engineers are ready to help you on any problems where pneumatic or hydraulic power should be applied.

The New Hi-Po Supercharged 3,000-Lb. Hydraulic Pump—Driven by a ½-HP Motor—Delivers smooth, chatter-free power—Builds Up Pressure Fast—Widely Adaptable for Hydraulic Power Applications.

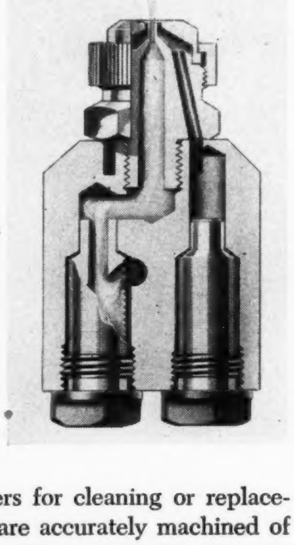


Anker-Holth Mfg. Co.

332 S. Michigan Ave. Chicago 4, Ill.

in addition to saving weight assure clean, oil-free air. The compressor will operate in any position and requires ¼ horsepower input. Its overall size is 9½ inches in height, 6 inches in diameter. Precision ball bearings are sealed in, requiring no lubrication, and vibration and noise are held to a minimum. The model shown in the accompanying illustration, as well as a Master twin compressor with double capacity, is available.

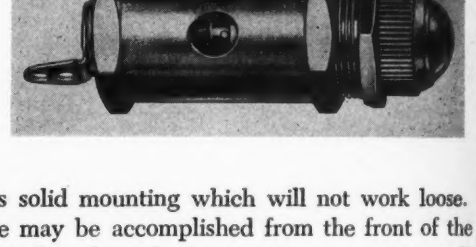
Pneumatic Atomizing Nozzle



An improved type of pneumatic atomizing nozzle for humidification systems is being offered by Spraying Systems Co., Chicago. In the nozzle, known as Type JHS, water and compressed air are mixed externally to produce a round spray which is projected from 10 to 20 feet depending on air pressure used in the system. Two monel metal strainers are included in the body of the nozzle, one for air and the other for water, permitting easy removal of strainers for cleaning or replacement. All parts of the nozzle are accurately machined of brass and white coated. Because the unit is complete in itself, it can be quickly and easily adapted to almost all types of installations where close control of atmospheric conditions is required. According to the company the design of the new valve contributes to lower operating costs, improved atomization, and longer life.

Pilot Lights for Panels

Measuring approximately 2 inches in length, a new series of pilot lights has been designed for grounded pilot light panels by Gothard Mfg. Co., 1300 North Ninth street, Springfield, Ill. The lights mount on 1-inch centers, permitting a number of units to be incorporated within a small space. Body of hexagon design facilitates the use of a socket wrench in installation and



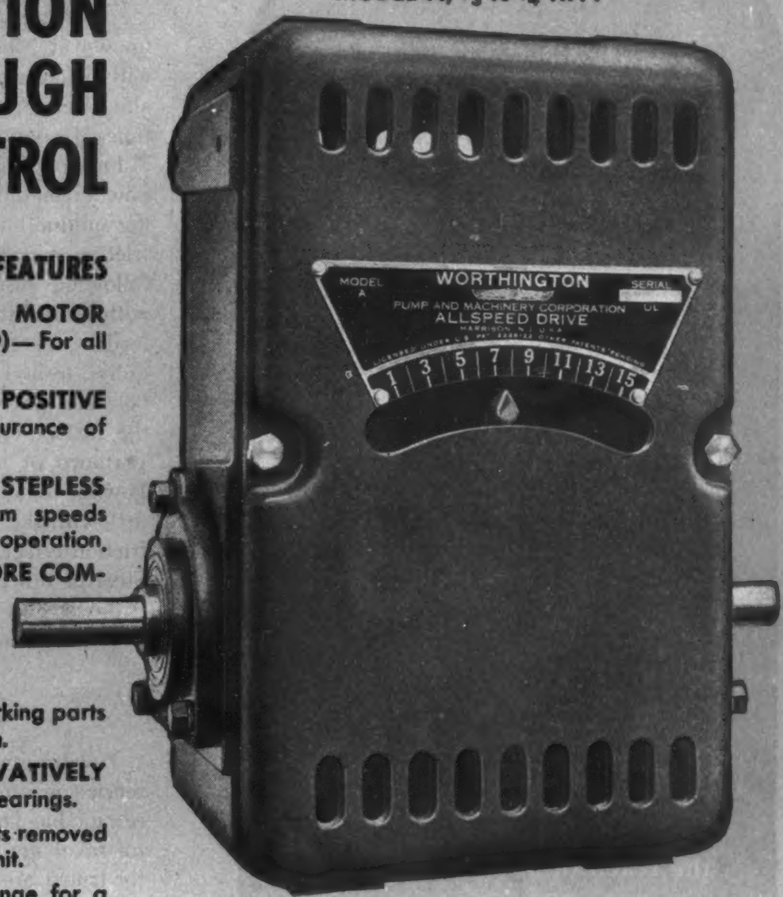
insures solid mounting which will not work loose. Bulb change may be accomplished from the front of the panel without disturbing body mounting or wiring. Bayonet socket lamps (long or round) may be used. The pilot light is available with faceted or plain lenses.

PEAK PRODUCTION SPEEDS THROUGH FINGER-TIP CONTROL

with these

WORTHINGTON ALLSPEED DRIVE FEATURES

MODEL A, 1/3 to 3/4 H.P.



- **16:1 RATIO (FROM ONE-EIGHTH MOTOR SPEED TO TWICE MOTOR SPEED)**—For all speeds for all needs.
- **THE ONLY DRIVE WITH AUTOMATIC POSITIVE BELT TENSIONING** — No springs. Assurance of smoother overall operating efficiency.
- **INSTANTANEOUS AND SMOOTH STEPLESS CONTROL**—Minimum through maximum speeds with a "finger-tip touch" while unit is in operation.
- **SINGLE-UNIT CONSTRUCTION . . . MORE COMPACT THAN ANY DRIVE IN ITS FIELD** —Can be installed in any position. Applicable to any machine . . . new or old. Easily accessible.
- **SIMPLICITY OF DESIGN**—Minimum working parts . . . no springs . . . trouble-free operation.
- **STURDY CONSTRUCTION . . . CONSERVATIVELY RATED**—Oversize retainer type ball bearings.
- **LOW MAINTENANCE COST**—Belts removed easily and quickly without dismantling unit.
- **AVAILABLE FROM STOCK**—Arrange for a demonstration today by writing the authorized WORTHINGTON ALLSPEED DRIVE DEALER in your area, or the nearest Worthington District Office.

THE WORTHINGTON ALLSPEED DRIVE

has been thoroughly job tested on many applications. It has proved its efficiency and stamina on a wide variety of work, including the finest precision jobs.

Reports from plant engineers and time study men show an increase in production ranging from 25% to 200%.

The Worthington Allspeed Drive will also play an important part in your training of inexperienced help by allowing you to increase the speed of the driven unit to parallel the growing experience of the operator . . . for maximum production with minimum spoilage.

Designed specifically to speed up war production by finding the peak production speed of any productive unit.

TV3-15

WORTHINGTON ALLSPEED DRIVE

WORTHINGTON PUMP AND MACHINERY CORPORATION • GENERAL OFFICES: HARRISON, N. J.

Powder Metal Machine Parts

(*Concluded from Page* 127)

the part is successfully used to withstand extreme shock. Shown at *j* is a clutch disk made of a brass composition with a fine graphite evenly dispersed throughout the metal. Used in a government instrument, it provides many times the service life of conventional materials.

Friction linings represent an important application of powder metallurgy for the creation of new materials having unique characteristics. Hitherto the most satisfactory friction materials have suffered from one or both of the following disadvantages: Coefficient of friction varies with temperature, and materials tend to store rather than to dissipate heat. When it is realized that the energy required to brake a bomber landing on the runway of an airfield can generate a temperature of 1200 degrees Fahr. at the surface of the brake linings in 6 to 8 seconds, the importance of a high rate of transfer needs no emphasis. Powder metal linings of copper (for high heat conductivity) with the addition of certain ingredients to control the friction effect, serve the purpose as no other material can. Steel or other backings are used to furnish the necessary strength, the backing and facing being bonded together during the sintering stage.

Powder Metal in Clutch Facings

Powder metal clutch linings are performing valuable service in aircraft for two-speed supercharger drives and retractable landing gear mechanisms, as well as in tanks for revolving turret mechanisms. Typical clutch elements for trucks are illustrated in *Fig.* 9. In this type of service clutch mileages of 100,000 are claimed compared with about 15,000 miles for some other types of lining. The powder metal clutch facing in one particular bus served for 351,819 miles before renewal.

Filters of powder metal may be so porous that light can be seen through a part ⅛-inch thick. Such filters find extensive use in fuel lines for fighting machines, particularly airplanes and tanks and equipment using diesel engines.

Among developments shortly to be expected on a commercial scale are hot pressing for the production of denser parts, centrifuging for the creation of pressure instead of pressing, and combinations of powder metal and plastics for the creation of a wide range of new materials.

Producers of powder metal parts, as previously indicated, are rapidly acquiring the experience that is enabling them to offer expert advice on design of new and unusual parts. Having been forced to tackle unusual jobs under pressure of war, they will be found ready and willing to undertake the solution of new problems. Designers can take advantage of the experience of these powder metal engineers by consulting them on the possibilities of new and improved parts.

MACHINE DESIGN is pleased to acknowledge the cooperation of the following companies in the preparation of this article: Bound Brook Oil-less Bearing Co.; Chrysler Corp., Amplex Div. (*Fig.* 1); The General Metals Powder Co. (*Figs.* 2, 4, 6 and 9); Hardy Metallurgical Co. (*Fig.* 7); Keystone Carbon Co. (*Fig.* 8); Powder Metallurgy Corp. (*Fig.* 5); The United States Graphite Co.; Westinghouse Electric & Manufacturing Co. (*Fig.* 2); and The S. K. Wellman Co.


Albanene
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the stabilized
TRACING
PAPER

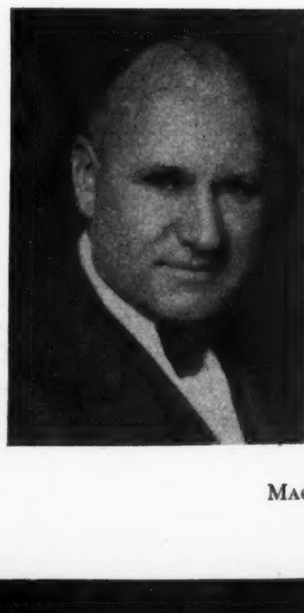
MEN OF MACHINES

FOR the past two years chief engineer in charge of radio communications equipment development, Palmer M. Craig has been named chief engineer of the radio division, Philco Corp. Mr. Craig joined the Philco Research Laboratories as a radio engineer in 1933 and assisted in the development of high fidelity reception, automobile radios and the first remote-control radio receiving sets. In 1938 he was appointed engineer in charge of console radios, and prior to Pearl Harbor took a leading part in the company's development of electronic equipment. A graduate of the University of Delaware in 1927 with a B.S. in electrical engineering, he formerly had been associated with Westinghouse Electric & Mfg. Co. Mr. Craig is certainly well equipped for his new post through his background in radio research and engineering.

♦

GOLD medal and research awards were presented by the American Society for Metals during the Metal Congress to Roy A. Hunt (right), president of the Aluminum Co. of America, and Zay Jeffries (left), technical director, lamp department, General Electric Co.

Under the guidance of Mr. Hunt, recipient of the research award, the Aluminum company has been a leader



Very light in weight, because they're made of magnesium, these tanks help increase a plane's "payload" capacity. Built, accurately, on a production basis for use on an airplane assembly line, schedules are high, while costs are held down. In service, these tanks preserve the quality of the oil they carry, for magnesium does not attack, nor is it attacked by, the oil.

Do these properties of a wartime magnesium product suggest ways of improving what you will manufacture in peacetime?

American Magnesium's facilities, which made possible a quick change-over to this kind of production when the emergency first arose, will be available to you for that peacetime production. The knowledge of design and skill in manufacturing gained in more than twenty years of working with magnesium will be yours for the asking. Our engineers will be glad to advise you on how best to employ this lightest of the lightweight metals.

Send for a free copy of the new book, "Designing with Magnesium". American Magnesium Corporation, 1703 Gulf Building, Pittsburgh, Pennsylvania.

MAGNESIUM **MAZLO** PRODUCTS

REG. U.S. PAT. OFF.

AMERICAN MAGNESIUM
CORPORATION

SUBSIDIARY OF ALUMINUM COMPANY OF AMERICA

in the research and technical development of a metal which has had its industrial growth in the past fifty-five years. By consistently sponsoring research and development, he has helped substantially to advance the arts and sciences relating to metals. With his father a pioneer metallurgist instrumental in organizing the Pittsburgh Reduction Co. for reducing aluminum by the electrolytic process, and with Mr. Hunt's being connected with the Aluminum company later as a young man when the metal was in an experimental stage, he was practically "raised on aluminum". He graduated from Yale in 1903 and joined the Pittsburgh company. He served in many capacities during the following years, until in 1919 he became vice president in charge of both fabricating and reduction plants. On June 4, 1928, he was named president.

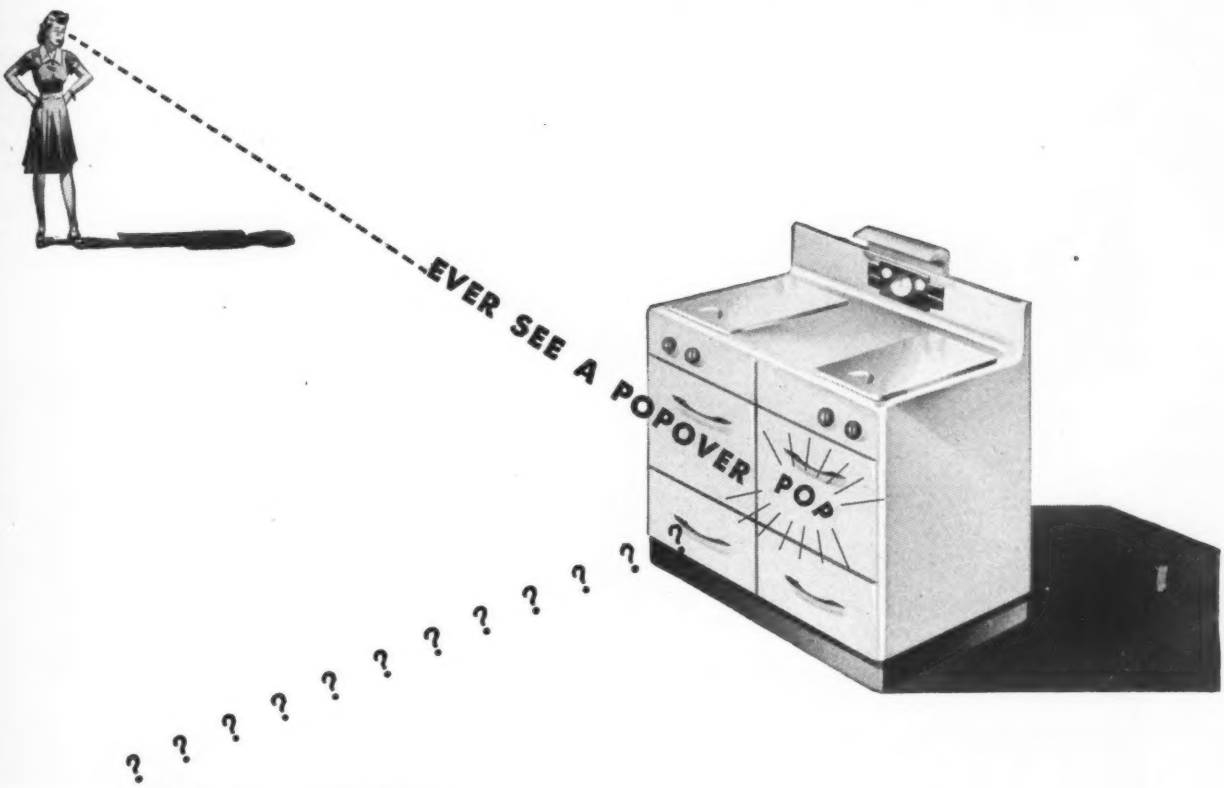
Zay Jeffries, who received the gold medal, graduated from the South Dakota State School of Mines and became an instructor in metallurgy at the Case School of Applied Science. Later he received his Doctor of Science degree at Harvard university. Resigning his faculty position at Case, he became technical director of the lamp department at General Electric Co. and director of research of Aluminum Castings Co. Dr. Jeffries is also chairman of the board of Carboloy Co., and of the metals conservation and substitution group, National Research council.

♦

Bert H. Norem has recently been appointed assistant professor of administrative engineering in the College of Applied Science, Syracuse university, Syracuse, N. Y. He previously had been an industrial engineer with Carrier Corp., during which time he also taught evening courses in motion and time study in the engineering, science and management war training program which the university is conducting.

♦

Associated with International Nickel Co. Inc. since 1922, T. H. Wickenden has been appointed manager of the development and research division of the company. He had been assistant manager of this division since 1931. Well known in engineering circles in the automotive industry, he was in charge of engineering at Studebaker corporation's South Bend plant from 1913 to 1920. For the next two years he worked with Chrysler, specifying materials for the first Chrysler car. He then joined International Nickel and was placed in charge of developments in the automobile field for the development and research department. Credited to him are numerous inventions connected with the use of nickel in cast iron, as well as outstanding papers and engineering data sheets on the use of nickel in steel and cast iron. With his engi-



WHAT'S SO SECRET ABOUT AN OVEN ANYHOW?

Equipping an oven with a glass window is not a new idea. You'll find this popular convenience on ranges in many homes today.

But oven door windows are just a starter. The stove we're suggesting (the stove of tomorrow?) not only utilizes fully the transparent and physical properties of modern glass, but it also typifies the many opportunities in product design that glass, as we make it, now opens up.

We've discussed with range manufacturers the practical benefits of stoves engineered to take better advantage of the characteristics of glass. The stove of the future may have more than double the vision that present oven door windows provide. You'll *really* be able to see what's cooking. Moreover—our tests are indicating that the outer surface of glass stays at room temperature longer than the metal it replaces. This not only points the way to a cooler kitchen, but also to a more efficient range.

Perhaps, too, inside the oven there will be a lining of a special glass. Indications are that less fuel is needed to maintain a given oven temperature when this more modern lining is installed.

Experiments are continuing. And as we go along we're pointing out to range manufacturers, and to other appliance people the many practical physical and chemical properties of glass. Here are just a few. It is unequalled in lasting transparency. Both chemically and dimensionally it is more stable than most materials. Its surface is among the hardest in the world; nonporous; acid-resisting; unusually resistant to abrasions; unequalled weathering qualities. We can make it stronger than many metals; provide it in flat sheets or bent shapes.

We'd like to tell you more about the many qualities of glass, about the many unusual developments of L·O·F research. Chances are that L·O·F glass now deserves serious consideration in your product or plant. Won't you write us about any use that interests you? That's the way to really find out. Libbey·Owens·Ford Glass Company, 11113 Nicholas Building, Toledo 3, Ohio.

Destructible?

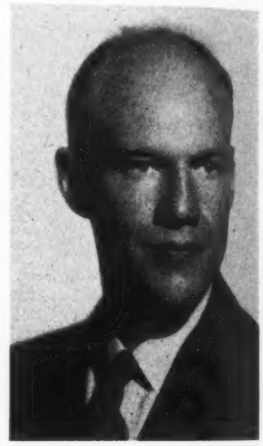
Wood-Metal-Plastics-Glass. No material is indestructible. However, barring unseen conditions, no material will fail on a job in which it has been properly specified and engineered. When our application engineers say "Yes", you can be sure about glass.

LIBBEY·OWENS·FORD

A GREAT NAME IN *Glass*

neering, designing and metallurgical background, his advice has often been sought by manufacturers to check engineering designs and specify materials and heat treatments. He collaborated in the design of several successful automobile racing cars, including the Dusenberg; of aircraft units, including autogyros, and more recently of helicopter parts. Also, he has recommended materials for ordnance and machine tool specifications, and has frequently advised on problems connected with heavy mining machinery. He also has been active in the introduction of special cast iron for wear-resistant parts in mining operations such as mill liners and wear-resistant pumps.

♦



RECENTLY announced is the appointment of W. F. Shurts to that of chief engineer of the hydraulic division of Twin Disc Clutch Co., Rockford, Ill. Mr. Shurts joined the company in 1940 as development engineer on hydraulic converters and hydraulic couplings. After graduating from Iowa State College in 1936 with a bachelor of science degree in mechanical engineering, he joined the Chrysler Corp. in its engineering division and entered the graduate school of Chrysler Institute of Engineering. From here he received his master of science degree in mechanical engineering in 1938. He then became engaged in development work for Chrysler on clutches and transmissions. Leaving Chrysler he joined Twin Disc as development engineer and continued to serve the company in this capacity through the time when the hydraulic division was moved from Racine to Rockford, and until his recent appointment.

♦

E. J. Sanders is the new vice president and director, as well as chief engineer of Kontrol-Fan Inc., Glendale, Calif., according to a recent announcement.

♦

William J. Russell has recently been named vice president in charge of engineering for Landers, Frary & Clark Co., New Britain, Conn. Prior to his appointment, Mr. Russell was manager of engineering at Westinghouse Appliance division, Mansfield, O.

♦

John A. Holbrook is now affiliated with Sperry Gyroscope Co. Research Laboratories, Garden City, N. Y., engaged in engineering work on aircraft instruments.

♦

Marcello A. King has been appointed executive engineer of the Moore Steam Turbine division, Worthington Pump & Machinery Co., Wellsville, N. Y.

♦

T. Claude Ryan, president, Ryan Aeronautical Co., San Diego, Calif., has been elected president of the Air-

craft War Production Council Inc., succeding LaMotte T. Cohu of Northrop Aircraft.

♦

R. C. Griffith has joined Denison Engineering Co. as manager of engineering and research. Mr. Griffith has a wide background in the field of oil-hydraulics, having been connected with the machine and tool design fields, automobile engine and chassis design, and later with Vickers in oil-hydraulics engineering.

♦

William J. Conley, former chairman of the engineering department, University of Rochester, has become connected with Lincoln Electric Co., Cleveland, as consulting engineer, handling problems on mechanical and structural design utilizing welding as well as metallurgical problems involving welding processes.

♦

Ralph Penn who has devoted much of his time to engineering and development for Penn Electric Switch Co., Goshen, Ind., has been appointed director of engineering.

♦

L. B. Ragsdale has recently become associated with Curtiss-Wright Corp. as manager of the airplane division department of its new development division. Mr. Ragsdale had previously been research engineer in charge of engineering on PT boat engines at Sterling Engine Co.

♦

Earl K. Clark, who during the twenty-one years he has been connected with Westinghouse has been responsible for many developments that improved electric appliances, has recently been appointed manager of the Westinghouse Appliance Engineering department.

♦

J. W. Peckham has been appointed manager of the development and design engineering department for The Bristol Co., Waterbury, Conn.

♦

Alexander Kennedy Jr., identified with marine engineering since 1919, has been named assistant to the manager in charge of engineering, General Electric Co. Mr. Kennedy has been connected with the company since 1908 and for the past ten years has been associated with propulsion turbines and gears designed for the Navy combat vessels.

♦

R. H. Hathaway, formerly assistant chief engineer for Hammond Machinery Builders, has joined the Packer Machine Co., Meriden, Conn., as sales and service engineer.

♦

A. J. Weatherhead Jr., president of Weatherhead Co., Cleveland, recently was presented with a citation for "inventive ingenuity which resulted in war production designs that have saved large quantities of critical materials and many machines and man-hours". The citation was presented by Col. Harold M. Reedall, chief of the Cleveland Ordnance district.

♦

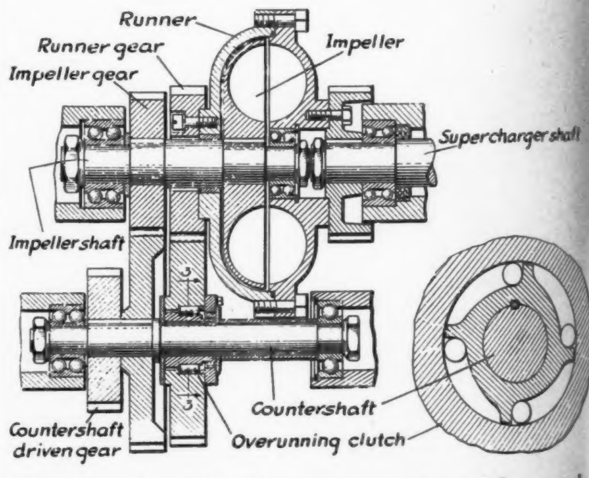
Igor I. Sikorsky has won one of the four awards in the sixth annual American Design Competition for his helicopter and 4-engine amphibian. Mr. Sikorsky is connected with Sikorsky Aircraft division, United Aircraft Corp.

NOTEWORTHY PATENTS

Insures Positive Drive with Fluid Coupling

SUDDEN increase or decrease in speed of an engine employing a gear-driven supercharger may damage the transmission and shafting due to the rigid and inelastic nature of the drive. Introduction of a hydraulic coupling into the drive provides the necessary flexibility but renders the supercharger inoperative at extremely low engine speed when the coupling ceases to function due to excessive slip. With such a coupling it therefore is necessary to provide means for by-passing the coupling at low speeds. A design incorporating this feature is covered by patent 2,326,570 recently assigned to Twin Disc Clutch Company.

Countershaft driven gear, as indicated in the illustration, meshes with a suitable gear on the engine crankshaft or camshaft. Also keyed to the countershaft is a pinion that meshes with the impeller gear associated with the hydraulic coupling. Runner of the coupling is attached to the supercharger drive shaft. At normal operating speeds the drive is through the impeller gear, impeller shaft, impeller runner, and supercharger shaft.



When coupling slip becomes excessive at low speeds, supercharger receives positive drive through overrunning clutch, shown in detail at lower right

Attached to the runner is a runner gear which meshes with a corresponding gear on the countershaft. However, this gear is not keyed to the countershaft, but is connected to it through an overrunning clutch consisting of a series of rollers interspersed between the sleeve on the countershaft and the gear. When the countershaft speed is higher than the speed of the gear, the rollers are moved outwardly to establish a clutching connection with the internal surface of the pinion. This occurs whenever the speed drops so low that the slip in the hydraulic coupling

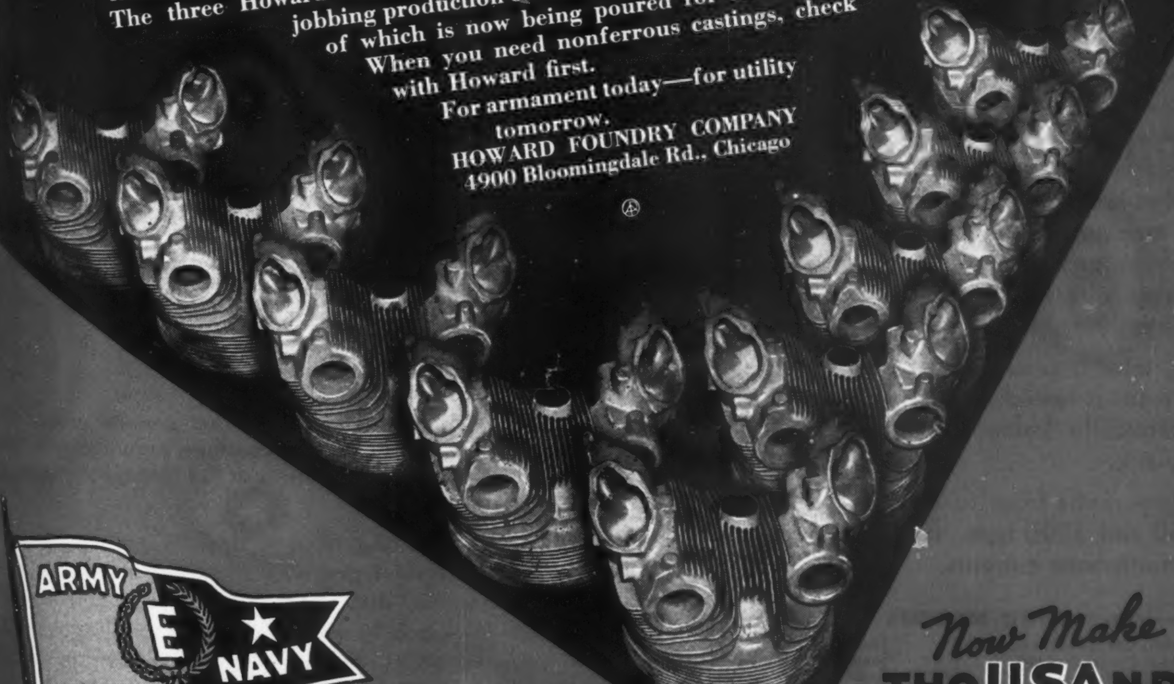
WARTIME LESSONS

in Aluminum Castings

According to WPB figures, the average American-built war plane contains seven and one-half tons of aluminum; some of the larger bombers carry more than double that weight of aluminum parts. Aluminum castings are an important part of this tonnage. It has been our privilege to produce a part of this tremendous volume of aluminum castings for planes and other armaments. Some of these castings go far beyond pre-war limitations in size — others are of extremely intricate shape and coring. Plane and engine builders have learned that there is no aluminum casting job too large, too small or too complex for Howard Foundry. Deliveries are made on schedule—or sooner. Current accomplishments in aluminum castings indicate more extensive peace-time applications. In aircraft this is definitely assured. To mention another field—trucks and buses—weight savings of great value will be secured by the broader use of aluminum cast parts in the designs of tomorrow and we hope to figure prominently in these revolutionary improvements, which will embrace a wide range of products. The three Howard foundries—aluminum, magnesium, bronze—embody the largest jobbing production of nonferrous castings in America; all of which is now being poured for the war effort. When you need nonferrous castings, check with Howard first.

For armament today—for utility tomorrow.

HOWARD FOUNDRY COMPANY
4900 Bloomingdale Rd., Chicago



ARMY E NAVY

Now Make THOUSANDS *More*

HOWARD

ALUMINUM · BRASS · BRONZE · MAGNESIUM

CASTINGS

becomes excessive, the drive then going through the overrunning clutch, the runner gear and the supercharger shaft. In one particular instance the free-wheeling connection was designed to accommodate a 15 per cent slip. The change from coupling to gear drive and vice versa is accomplished automatically in response to changes in speed of the engine.

Angle Drive Employs Multiple Pinion

A right-angle, multiple bevel gear drive capable of transmitting a large amount of power, yet more compact and lighter in weight than a single large double gear unit, is the subject of patent 2,326,860, recently assigned to Wright Aeronautical Corp. Advantages of this type of drive are illustrated in *Fig.* 1. The new design enables employment of a radial engine in an aircraft with a slender fuselage by placing the engine with the crankshaft in a vertical plane and the cylinder in the plane of the wing, thus presenting a profile of small area. Further, it facilitates the installation of a cannon firing through the propeller hub.

As shown in *Fig.* 2, there is provided a transmission

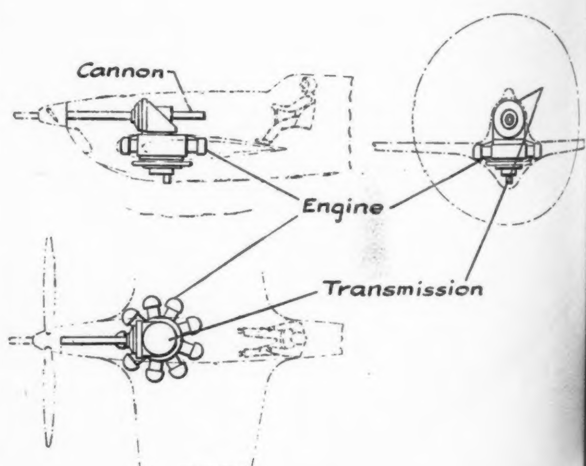


Fig. 1—Angle-drive transmission permits installation of radial engine in a slender fuselage, reducing aerodynamic drag, also allows cannon to fire through propeller hub

housing consisting of a vertical disk or ring tangent at one edge and integral with a horizontal ring. Upper edge of the vertical disk and right-hand edge of the horizontal disk are joined by an elliptical ring or plate sloped at an angle of about 45 degrees with respect to the disks. Multiple layshafts supported by the housing each carry at one end a bevel pinion and at the other end a spur pinion meshing with a ring gear. These shafts are circumferentially disposed relative to the ring gear and are of different lengths. Through the bevel gears they drive a similar set of shafts geared to a driven ring gear. Total length of all shaft sets is the same, hence the torsional rigidity is the same so that the driving torque from the ring gear is divided equally between the several bevel gear connections.

Because the driving torque is equally divided among a number of small high-speed gear connections the aggregate bulk and weight of the assembly is substantially

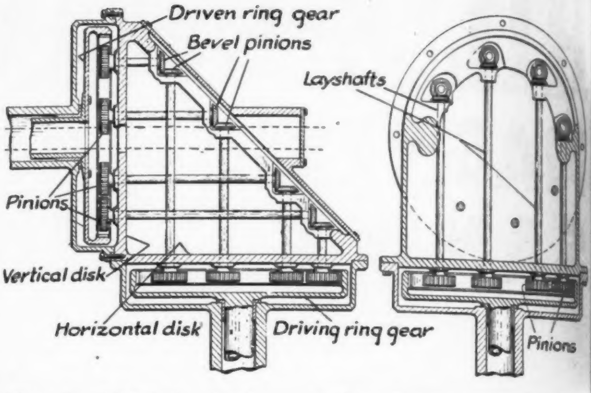


Fig. 2—Multiple high-speed bevel gear units provide right-angle drive transmission capable of handling large amount of power as in aircraft

less than a single large bevel gear connection between the driving and driven shafts. Further, the disposition of the shafts and gears is such that a passage concentric with the driven gear may be established through the transmission, as represented by the dotted lines in the left-hand view, this passage permitting the installation of a gun through the transmission when the latter is used as an aircraft propeller drive.

Constant Velocity Universal Joint

CONSTANT velocity universal joints employing the medium of hardened balls to transmit torque hitherto have required the assistance of a ball cage or other means for locating the balls and preventing axial separation of the driving and driven elements. A design which eliminates the cage and is capable of being readily assembled and disassembled is covered by patent 2,321,448, recently assigned to Borg-Warner Corp.

As shown in the accompanying drawings, the coupling comprises an outer and an inner element provided with raceways which accommodate the balls. The outer element is formed integrally with the shaft while the inner is splined on its shaft but locked to prevent relative axial movement. Matching surfaces of the outer and inner elements are spherical. Raceways are inclined circumferentially, the direction of inclination being opposite for the outer and inner members. Raceways also are inclined radially but alternate raceways in each member are inclined in opposite directions, as comparison of the two left-hand views shows. Conforming to the cross-sectional contour of the balls, the raceways are semicircular in shape.

Torque Causes Wedging

Torque applied to the balls in one direction will cause one series of alternate balls to be urged toward the plane of intersection of the crossed pairs of raceways, resulting in wedging of the balls against the converging bottoms of their respective pairs of raceways. For example, driving torque applied to the outer element in a clockwise direction, indicated by arrow *f*, will cause the series of balls shown in the lower view to be urged toward the right as far as permitted by the converging bottoms of the

To help you SOLVE TUBING CONNECTION PROBLEMS

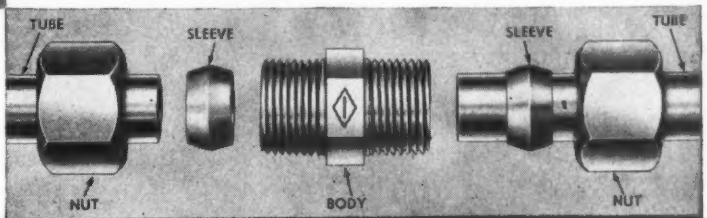
FOR many years the Imperial organization has been working with manufacturers on the problem of selecting the right fittings to best handle specific tubing connection problems. The types of Imperial fittings that are used in connecting up fuel, lubricating oil, water, air, refrigerant, and other lines are illustrated here for ready reference.

If you have problems that involve the use of tubing connections on essential war equipment or on production machines that are turning out war products, we should be pleased to supply you with detailed information on any, or all, of these types of fittings.

THE IMPERIAL BRASS MFG. CO., 513 S. Racine Ave., Chicago, Ill.

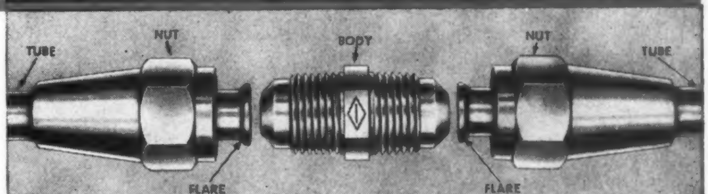
IMPERIAL COMPRESSION FITTING

The Imperial Brass Manufacturing Company originated this compression type fitting which has been widely used in the industrial and automotive fields. No soldering, flaring or threading is necessary The loose sleeve slips over the tubing and is seated by compression when the nut is tightened.



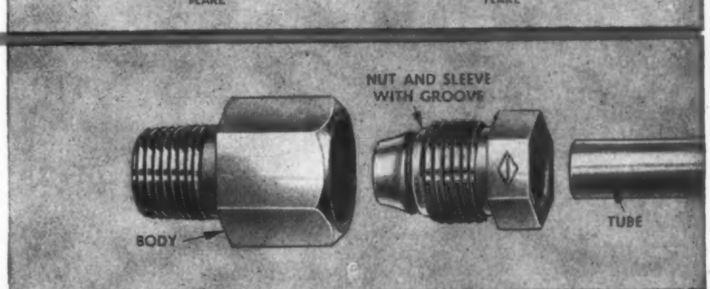
IMPERIAL S.A.E. FLARE FITTING

The Imperial S.A.E. Flared Fitting is especially adapted for high pressure service and has the advantage that it will withstand a severe tensile pull without failure. This fitting is widely used in industrial and automotive applications and in such services as refrigeration.



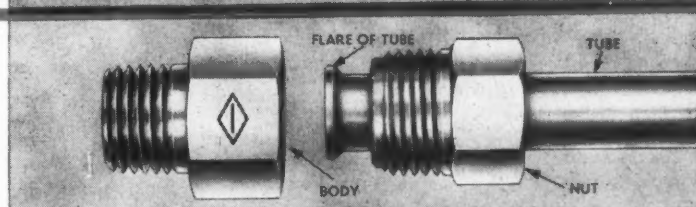
IMPERIAL HI-DUTY FITTING

This fitting is an improvement on the compression design. It consists of a nut with a grooved sleeve and a body When the nut is tightened the sleeve shears off and compresses on the tube and becomes a permanent part of the tube. The correct alignment of the sleeve is also automatically maintained. When assembling there is no loose sleeve to contend with and the Hi-Duty fitting stands up much better under vibration. It can be coupled and recoupled at will and always reconnects tight.



IMPERIAL INVERTED FLARE FITTING

In this fitting the nut screws into the body instead of over the body. This fitting is used in automotive applications excepting in close connection work.

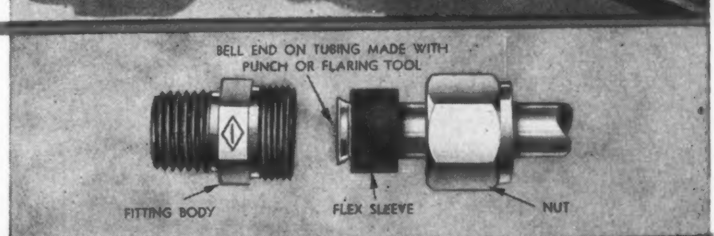


IMPERIAL TYPE "FN" FITTING

This fitting was developed for use with flexible tubing. It is a three piece compression fitting with a built-in grommet to prevent the tube from collapsing This fitting is widely used on war equipment and on trucks, buses, tractors, and similar applications where the use of flexible tubing is required due to extreme vibration and tube movement.

IMPERIAL FLEX FITTING

This fitting was developed for applications where extreme vibration is encountered and where the vibration between the different parts to be connected is in different planes and amplitudes, but where only minor tube movement is involved. In this fitting a sleeve made out of synthetic elastic material is used



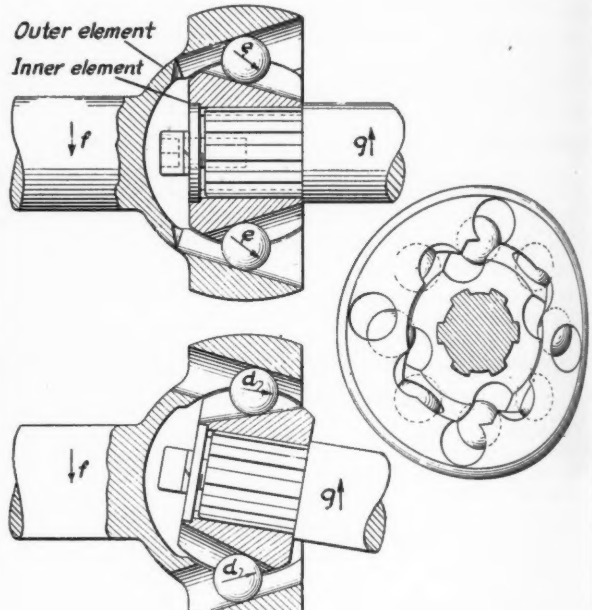
IMPERIAL

TUBE FITTINGS AND COUPLINGS FOR COPPER, BRASS, STEEL, ALUMINUM AND SYNTHETIC TUBING, SHUT-OFF COCKS, STRAINERS, TUBE CUTTERS, BENDERS AND FLARING TOOLS

raceways, as indicated by arrows *d*. This urging is the result of the wedging action of the crossed sides of the raceways against the balls.

The same torque which urges these balls into wedging engagement with the bottoms of their raceways, enabling them to transmit torque, tends to move the intervening series of balls toward the diverging ends of the bottoms of their raceways as indicated by the arrows *e* in the upper view. However, since relative rotation between the driving and driven elements is prevented by the balls through which torque is being transmitted, the balls in the upper view will be caged by the crossed sides of their raceways.

Parts are so designed that the centers of crossing of the raceways will always remain in a plane bisecting the axes



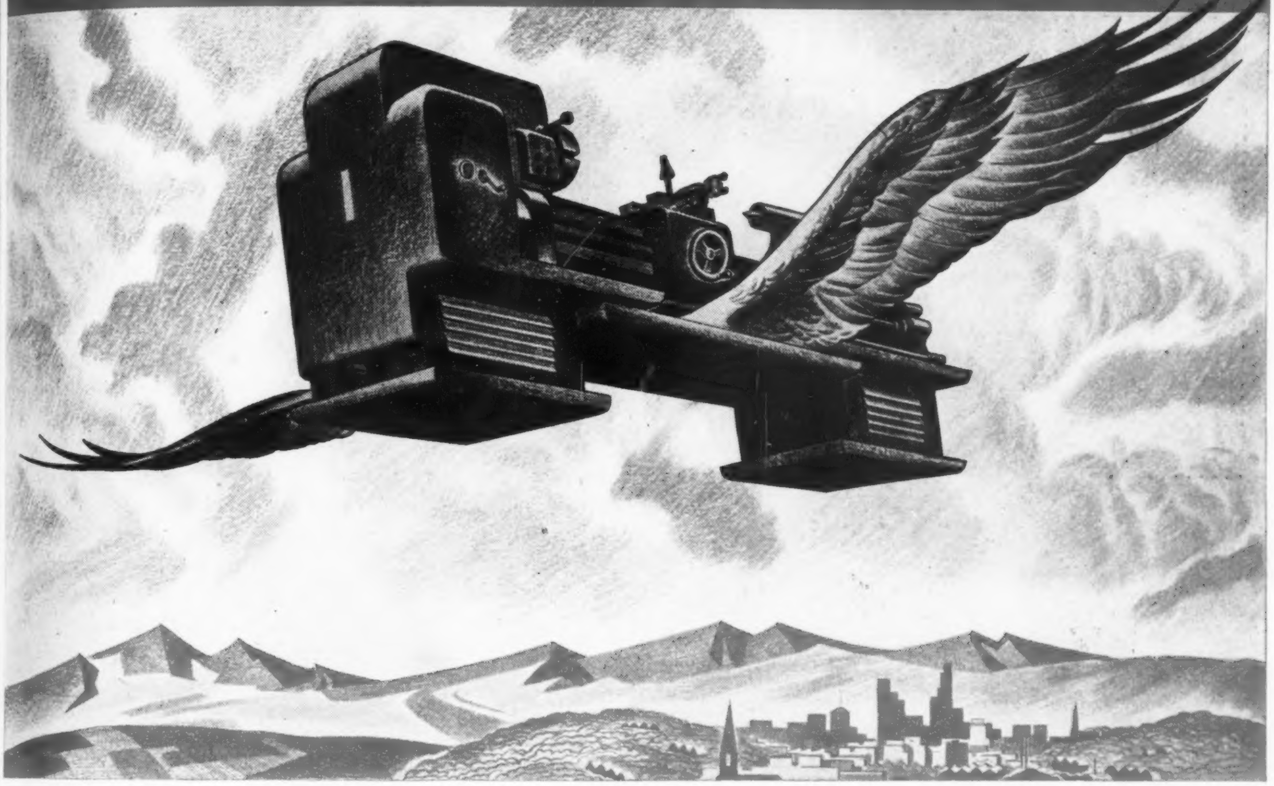
Torque is transmitted through series of balls operating in raceways which are inclined in both axial and radial directions. Alternate raceways have opposite axial slope

of the driving and driven elements, and as a result the driving series of balls will transmit torque at uniform velocity. Due to tolerances required for permitting free movement of the balls in their raceways, there will necessarily be a small amount of lost motion during reversal of torque. Subject to this motion, which is slight, the two series of balls will hold the two members against rotary or axial motion with respect to each other.

Inner element is formed independently of the shaft on which it is splined, in order to permit assembly and disassembly. Inner element is inserted into the outer by turning it until its axis is at right angles to that of the outer and inserting it edgewise through the mouth of the outer element. Extremities of the inner element are accommodated in cutaway spaces in the mouth of the outer element, disposed diametrically opposite to each other.

Balls are inserted by moving the inner element successively to positions in which the ends of the pairs of raceways substantially register with each other. To attain any of these positions it is necessary that the shaft be removed. After the shaft is inserted in the inner element it is impossible for the balls to escape from their raceways.

Suppose your Plant Equipment had to Fly..



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ASSETS to a BOOKCASE

The Physics of Metals

By Professor Frederick Seitz, Carnegie Institute of Technology; published by McGraw-Hill Book Co., 330 pages, 5½ by 8 inches, clothbound; available through MACHINE DESIGN, $4.00 *postpaid.*

Although this book deals specifically with the physical structure of metallic substances, it also provides a key to better understanding of the physicist's conception of all matter. A commendable effort is made to present an inherently complex subject in nonmathematical language, making it comprehensible to a varied readership.

Basic atomic theory is followed by a dissertation on the arrangement of atoms in metals and this is amply qualified by illustrations of crystal-structure lattices applying to a variety of common materials. Subsequent chapters cover such phases of the subject matter as: The periodic chart; substitutional and interstitial alloys; physical form of alloys; elastic properties of crystals; plastic properties of single crystals, polycrystalline media, and alloys; creep and secondary plastic effects; internal friction; rupture and fatigue; diffusion in metals; solubility of gases in metals; properties of iron-carbon alloys; development of electron theory of metals; band theory of solids; cohesion of solids; magnetic properties and electrical conductivity of metals.

Designers who desire a well-rounded general knowledge of metallurgy will find this book interesting and highly informative.

□ □ □

Patent Law

By Chester H. Biesterfeld, B.Ch.E., M.P.L.; published by John Wiley & Sons, Inc., New York; 225 pages, 5⅜ by 8⅜ inches, clothbound; available through MACHINE DESIGN, $2.75 *postpaid.*

During recent years from 80 to 90 per cent of all patents coming before our courts have been held invalid. This is an astonishing fact which renders obvious the necessity for wider recognition of patent law principles on the part of technicians.

While there is no dearth of books dealing with patent procedure, this present treatise has much to commend it. True invention and discovery, both patentable, are carefully delineated and compared to the mechanical adaptation of old recognized principles and concepts, apparent simple improvements and the many types of pseudo-inventions, all of which are nonpatentable. Significant legal trends in the patent field are noted and explained as is the basic tendency toward higher standards in patent grants.

Complete coverage of the subject includes: Novelty;

priority of invention; originality; abandonment; functional claims; double patenting; interferences; infringements; licenses; trade secrets; searches and patent litigation.

□ □ □

Plywoods

By Andrew Dick Wood and Thomas Gray Linn; published by Chemical Publishing Company, Inc., Brooklyn, N. Y.; 373 pages, 5⅜ by 8½ inches, clothbound; available through MACHINE DESIGN, *$4.00 postpaid.*

With the increasing utilization of plywood as a construction medium in aircraft, ships, auto trailers, etc., as well as through the apparent potentialities of the material in many engineering fields, this book undoubtedly will find a ready audience.

Following a chapter dealing with historical background, the reader is familiarized with the types of plywood construction, characteristic structural properties of the various woods employed, manufacturing methods and equipment, and numerous prevailing applications.

Many photographs and drawings are employed to demonstrate how plywood is used in construction—this phase of the subject being treated in considerable detail—while the appendix offers a comprehensive glossary of terms commonly used in the plywood trade. The tabularized relative properties of commercial soft and hard woods should prove of particular interest to designers.

Treatment of Experimental Data

By Archie G. Worthing, University of Pittsburgh, and Joseph Geffner, Weirton Steel Co.; published by John Wiley & Sons Inc., New York; 342 pages, 5¾ by 9 inches, clothbound; available through MACHINE DESIGN, *$4.50 postpaid.*

Specifically aimed at the physicist, chemist and engineer, this highly technical treatise serves as a practical guide for clear, nonambiguous presentation of engineering data via tables, graphs and equations. Its intent is to define procedures in treatment of data, stressing the indigenous merits and limitations of each. Methods of interpolation, extrapolation, determination of probable errors, etc., are thoroughly explained, competent treatment being accorded such phases of the subject matter as: Representation of data by tables, graphs and equations; tabular and graphical differentiation and integration; Fourier series; normal frequency distribution; means and precision indexes of unequally weighted measurements; propagation of precision indexes; adjustment of conditioned measurements; least-squares equations representing observed data; correlation and analysis of nonharmonic periodic functions.

It might well be that through the efforts of men such as this book's authors, clear-cut standardization will be achieved covering the chart, graph and table methods of data presentation.

A brief discussion of determinant methods is offered in the appendix along with a number of pertinent tables, and a bibliography precedes the book's index.

DESIGN ABSTRACTS

Special Addition Agent Steels

THE TERM "special addition agent" refers to a group of ferroalloys containing boron, which have the property of markedly increasing the hardenability of many steels when added in relatively small amounts. These alloys are also known as "needling agents" or intensifiers". Main reason for the interest shown in these materials at this time is the promise they offer of conserving critical alloying elements. It now seems certain that, by suitable adjustment of steel chemistry, these alloys can be used to replace important amounts of such elements as nickel, chromium and molybdenum.

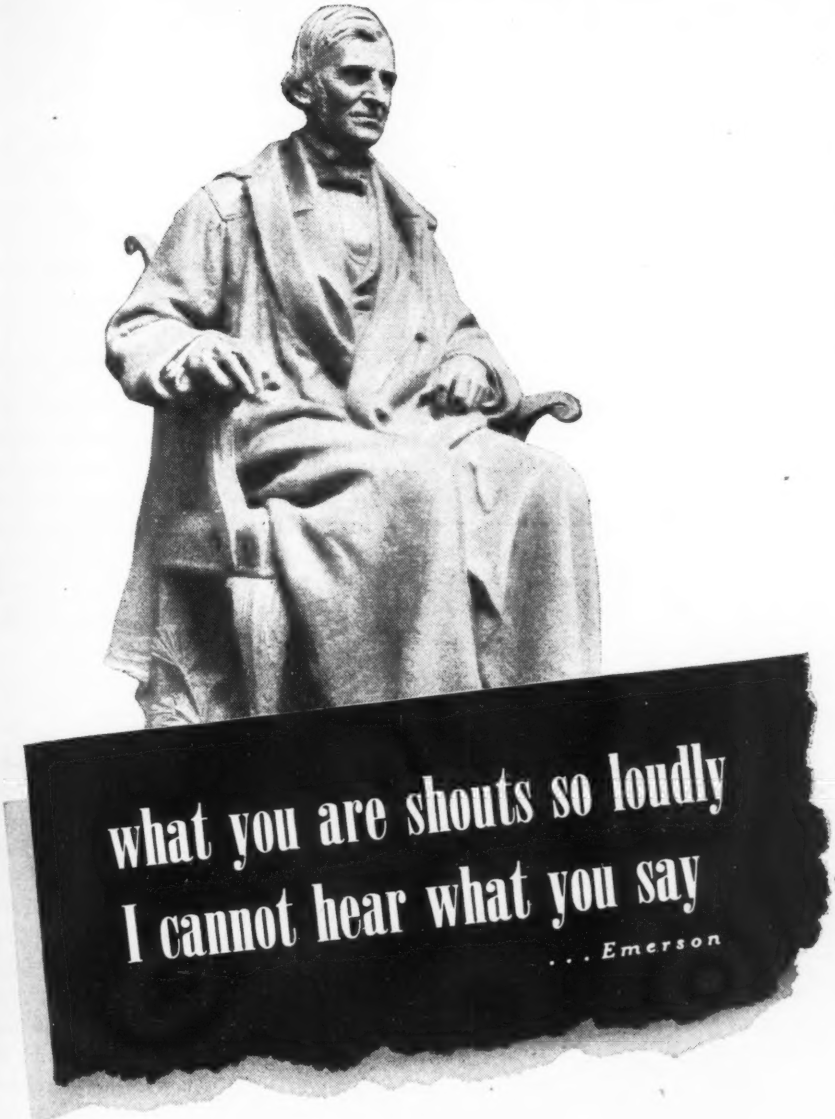
General effect of the special addition agents is to increase hardenability and improve the mechanical properties of steel in the quenched and drawn state. In other than the quenched and drawn state, the additive seems to lower the mechanical properties. Although there may be exceptions, this tendency has been noted in a number of instances. The improvement in mechanical properties resulting from an additive treatment is confined mostly to the plain carbon and low alloy steels, and this improvement is most pronounced at low draw temperatures in the range of 300 to 500 degrees Fahr. In general it may be stated that, with respect to hardenability and mechanical properties, a special addition agent treatment can make a carbon steel equivalent to a low alloy steel and a low alloy steel equivalent to a high alloy steel.

Used for Automotive Parts

First commercial applications of these steels were made in the automotive industry. There are thousands of Buick motor cars on the roads today with special addition agent steels in such vital parts as steering knuckles, steering arms, knuckle supports, transmission gears, transmission main shafts, differential gears and axle shafts. Performance of these parts has been entirely satisfactory. Other manufacturers of automotive vehicles have used addition agent steels successfully in passenger cars and trucks.

Comparing fabricating characteristics of treated carbon and manganese steels with untreated steels of the same composition, the only noteworthy difference found in the shop was the improved machinability of the treated higher manganese types. As one member of the organization remarked, "These steels (treated 1.00-1.30 manganese) anneal and machine like carbon steels and heat treat like alloy steels." Forging qualities of the treated steels appeared to be as good as those of the same compositions untreated.

No standard specifications, such as WD, SAE, AISI, or ASTM, now exist for special addition agent steels. It



What a product is, how it meets the test of use, what its record is in service shouts louder than any words that may be written about that product in an advertisement. The fact that Hoover Balls and Bearings are in use today in practically every type of equipment serving on the battle-fronts and at home behind the lines, is our most effective advertisement on Hoover quality and dependability. Hoover products are eloquently speaking for themselves in hundreds of munitions of war, a few of which are listed at the right.

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Mine Sweepers
Searchlights
Powder Plants
Gun Directors
High Explosive Shells
Cranes and Hoists
Telephones and Telegraph
Bomb Fuses
Anti-Aircraft Guns

★

And hundreds of other equally important applications.

has become obvious that chemistry alone will not suffice; the small amounts of special elements remaining from the additive treatment are difficult to determine accurately and their presence does not necessarily guarantee that the desired effect has been obtained. It is now apparent that hardenability and possibly mechanical properties will be required in addition to chemistry.

Tentative specifications, including chemistry, minimum hardenability and a merit index based on tensile strength and reduction of area, have been formulated and are now receiving serious consideration. The merit index, referred to as the "*P* value", is used to evaluate the tensile properties. It is obtained from the following formula:

$$P = \frac{T + 6R}{5}$$

where P = merit index or "P value", T = (tensile strength, psi) /1000, and R = reduction of area, per cent. A P value of 100 is considered to be a fair average for alloy steels fully quenched in light sections and drawn at 900 to 1100 degrees Fahr. Higher P values denote superior and lower P values inferior tensile properties. By specifying a minimum tensile strength and a minimum P value the relationship between strength and ductility is thus expressed by a single number.

Specifying by Hardenability

Hardenability is expressed by means of a code or index as explained under "Methods of Hardenability Testing" in the SAE Handbook. Thus, the terms "Hardenability J-50", or merely "J-50", denote the point on the hardenability curve at which the hardness is rockwell C 50. If the distance of this point from the quenched end of the bar is, for example, 8/16-inch, then the value for J-50 is 8. The reference points or J-numbers used here for different carbon contents are J-40 for .20 carbon, J-45 for .30 carbon and J-50 for .40 and .45 carbon. These are purely arbitrary values which have been found to work satisfactorily. They are approximately 10 points rockwell C below the maximum quenched hardness for each carbon content.—*From a paper by R. B. Schenck, chief metallurgist, Buick Motor Division, presented at the recent National Tractor Meeting of the Society of Automotive Engineers.*

Simplification and Standardization

SIMPLIFICATION as we conceive it may be defined as the elimination of those items, types, sizes and colors of products which do not serve the war effort; in fact, many of which do not serve any economical purpose. In most instances they are a positive hindrance to the flow of essential products to the armed services and to civilians. To make simplification effective, a certain amount of standardization is usually necessary. Often it is only a single element in a product that must be standardized in order to achieve the necessary degree of simplification. Another important role played by standards is to provide for interchangeability, particularly in combat equipment.—*From a paper by Howard Coonley, Chairman of the Conservation Division, W.P.B., presented at the recent joint meeting of the A.S.M.E. and the Engineering Institute of Canada.*

PROBLEMS THAT COME TO GILMER

Can You Control the Stretch of V-Belts?

A compressor manufacturer was having considerable difficulty because of excessive slippage of V-Belts on his drives. Too much stretch in the V-Belts not only caused the slippage, but wore out the belts very quickly. Gilmer Engineers were called in and they developed a process to "normalize"* the cords . . . thus bringing stretch under control.

A V-Belt must have *some* stretch...a certain amount must be retained to prevent a brittle condition which affects tensile strength. That's why Gilmer uses normalized cords in V-Belts. Stretch is worked out of the cord in such a manner that it will neither shrink nor stretch. This gentle "working" does not injure the strands of the cord, but rather, insures long belt-life from less slippage. On all V-Belts, such efficient operation is vital . . . and economical.

The services of Gilmer Design Engineers are always available in solving belt problems. Write for Gilmer's Belt Catalogues. Don't hesitate to ask for help on design problems.

*A WORD ABOUT GILMER NORMALIZED CORDS

To prevent excessive stretch, Gilmer V-Belts are constructed with normalized cords . . . cords that have been worked to prevent subsequent shrink and stretch. This gentle "working" does not injure the strands of the cord, and in bringing the stretch under control, a certain elasticity is retained to prevent a brittle condition which would affect tensile strength. Consequently, Gilmer V-Belts are insured for longer life, less slippage, and little maintenance attention.

Gilmer BELTS

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V-Belts (F.H.P. & Multiple) · Flat Belts · Round Endless Belts · High Speed Belts · Fabric Belts · Planer Belts · Special Endless Belts

Spiral Springs

(*Continued from Page* 132)

$$r_2\phi=\frac{1}{EI}\int_0^l\Big[P(r_2+y)+M_1-Rx\Big](r_2+y)ds \qquad (31)$$

If the center line of the spring is taken in the form of a spiral, Equations 27, 29 and 31 may be integrated over the total length l. This gives three simultaneous equations in P, M_1 and R from which these latter quantities may be found. Knowing these, the bending moment M at any point may be found from Equation 26. By differentiation the location of the maximum value of the moment along the spiral may be obtained and from this the actual value of the maximum moment M_m. If M_o is the external moment (this is also the maximum moment for a spring with clamped ends and a large number of turns) the ratio M_m/M_o between maximum moment and external moment may be considered as a stress concentration factor. Values of this ratio M_m/M_o plotted in *Fig.* 6 as functions of the total spiral angle θ for various values of the function $\lambda=(r_2-r_1)/r_2$ have been obtained by Kroon and Davenport (4). (The value of θ is taken as the angle swept out by the radius vector in traveling from one end of the spiral to the other).

From *Fig.* 6 it is seen that the stress concentration effect due to a small number of turns is somewhat greater for the larger values of λ. In addition the stress concentration values are smaller when the total coil angle θ is near 360 or 720 degrees. This suggests that it is of advantage when designing spiral springs of this type to use a whole number of turns. From *Fig.* 6 it is also seen that as the total coil angle θ increases, the maximum values of the ratio M_m/M_o also decrease, i.e., the stress concentration effect decreases. However, even for $\theta=1080$ degrees (3 turns) and $\lambda=.6$, the ratio M_m/M_o is still equal to almost 1.2 which means that maximum stress will still be almost 20 per cent higher than that given by Equation 18, derived on the assumption of a large angle θ.

Spring Is Stiffer

In addition it will be found that because of the small number of turns the spring is somewhat stiffer than would be expected on the basis of the simple formula (Equation 17) derived for a large number of turns. The more accurate analysis (4) shows that the angular deflection at a moment M_o is given by

$$\phi=\frac{1}{\beta}\,\frac{M_o l}{EI} \qquad (32)$$

In this the factor β (which is greater than unity) depends on the total angle θ of the spiral and on the ratio λ. Values of this factor are given in *Fig.* 7. However, for ratios λ between .4 and .6 and for more than two turns of the spiral this factor differs from unity by about 4 per cent, and hence may usually be neglected for practical purposes, i.e., the usual formula (Equation 17) may be applied. However, from *Fig.* 7 it may be seen that a 15 per cent error is involved in the usual formula where $\lambda=.6$ for a spring with only one turn.

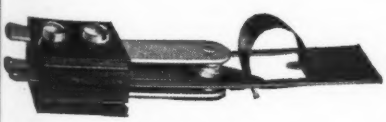
Values of the radial deflection at various points along

IT'S THE *Rolling Spring*

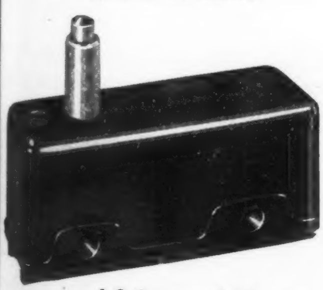
that assures better contacts and higher operating speeds

Acro Snap SWITCHES

1-A Pin Actuator



Open Blade Switch

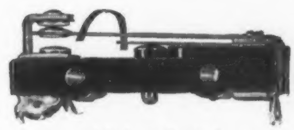


1-O Overtravel Plunger

● Better contact and higher operating speed is assured with the patented rolling spring ACRO SNAP SWITCH. When we say BETTER CONTACT we definitely mean BETTER CONTACT with the same operating pressure. This minimizes contact burning and greatly lengthens switch life. Many types of ACRO SNAP-ACTION SWITCHES are used in aircraft and other vital war equipment where unfailing performance is essential. If you have not yet handled and studied the ACRO rolling spring SNAP-ACTION SWITCH an experience is awaiting you.

IN WRITING, KINDLY EXPLAIN NATURE OF APPLICATION YOU CONTEMPLATE

Bracket Switch



Midget Switch

5-L Ribbed Leaf

ACRO ELECTRIC COMPANY • 1311 SUPERIOR AVE., CLEVELAND 14, OHIO

★ ★ ★

the spiral are of interest since in general the designer should try to avoid having the coils touch during deflection. These quantities have been worked out (4) as functions of the angle along the spiral for various numbers of turns and for various values of the ratio λ; the results are plotted in *Fig.* 8. The ordinates represent radial deflection δ divided by ϕr_2. In this ϕ is the angular deflection of the spring due to the external moment while ψ is the angle measured along the spiral from the outer end. By using these curves the necessary spacing between coils may be worked out for springs with various numbers of turns. For further details the reader is referred to reference (4).

Stress Concentration in Thick Spring

In the design of spiral springs where the thickness is fairly large, a further stress concentration enters due to the fact that the spring is, in effect, a curved bar. This stress concentration is usually small but may be determined for a given thickness and radius of curvature by using curves given in a previous article for torsion springs (5)

The curves of *Figs.* 6 and 7 apply only to spiral springs with clamped outer ends. Where the outer end is pin connected, an analysis may be carried out using similar methods, and more exact expressions for deflection and stress obtained. These expressions are rather cumbersome and for further details the reader is referred to the publication by Gross and Lehr (6).

Allowance for Fatigue Stresses

Calculated working stresses in spiral springs may run as high as 175000 to 250000 pounds per square inch or more where fatigue conditions are not a factor. For example, an ordinary clock spring during its life may be subject to less than 5000 cycles and hence may be stressed much higher than would be the case where millions of cycles are involved. Where fatigue conditions are present (as for example in the spiral spring for the balance wheel of a watch) the stress range should be kept well below the endurance range of the material, stress concentration conditions at the clamped edges being considered. Some data on endurance ranges in bending for spring materials are given in the writer's article (7).

Turns Delivered By Wound Spring

In cases where individual coils touch each other, as for example in the mainspring of a watch or the power spring of a phonograph, the spring is usually placed inside a hollow case as indicated in *Fig.* 9. Here the spring is shown wound up on the arbor. When the spring is unwound it rests against the inside of the case as indicated in *Fig.* 10.

The number of turns delivered by such a spring may be estimated approximately as follows (8). If l is total length of spring strip and h is the thickness, the total sectional area of the wound spring will be lh. But from *Fig.* 9 this is also equal to $(\pi/4)(d_2^2 - d_1^2)$ assuming that the coils are wound tightly so that adjacent turns touch, and neglecting the turns connecting the wound part with the case. Thus,

FROM WARTIME PLASTICS-BONDED PLYWOODS... THIS "PLAS-2-POINT HOUSE" FOR POSTWAR LIVING

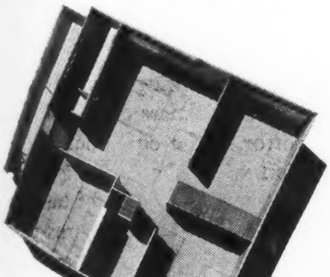
Architect Marcel Breuer, now professor in Harvard's department of architecture, trained, then taught at the famed Bauhaus. To his credit are the first tubular steel chairs and some of the best examples of contemporary architecture and industrial design here and in Europe.

HARVARD'S Marcel Breuer has pondered the skeleton of a modern bomber . . . probed the possibilities of war-born, new plastics-bonded plywoods . . . and produced this interesting and original design for postwar prefabrication which he has christened the "Plas-2-Point House."

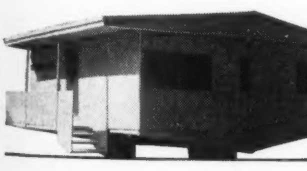
"Compared with current prefabricated construction," Mr. Breuer estimates, "the Plas-2-Point House would weigh a third as much, cost only 70% as much and, knocked down for shipment, would occupy only 30 to 40% as much packing space. Even fully assembled houses could be trucked short distances from central assembly lines to individual building sites, then quickly anchored to foundation blocks."

Since neither walls nor partitions are load-bearing, the "Plas-2-Point House" is highly flexible. Exterior wall panels might be heavily insulated for cold climates or simply a series of screens for the tropics. They might be built up from Resinox-bonded plywood with a durable, colorful, weather-resistant melamine surface—or even from paper or fabrics impregnated with Resinox and melamine resins.

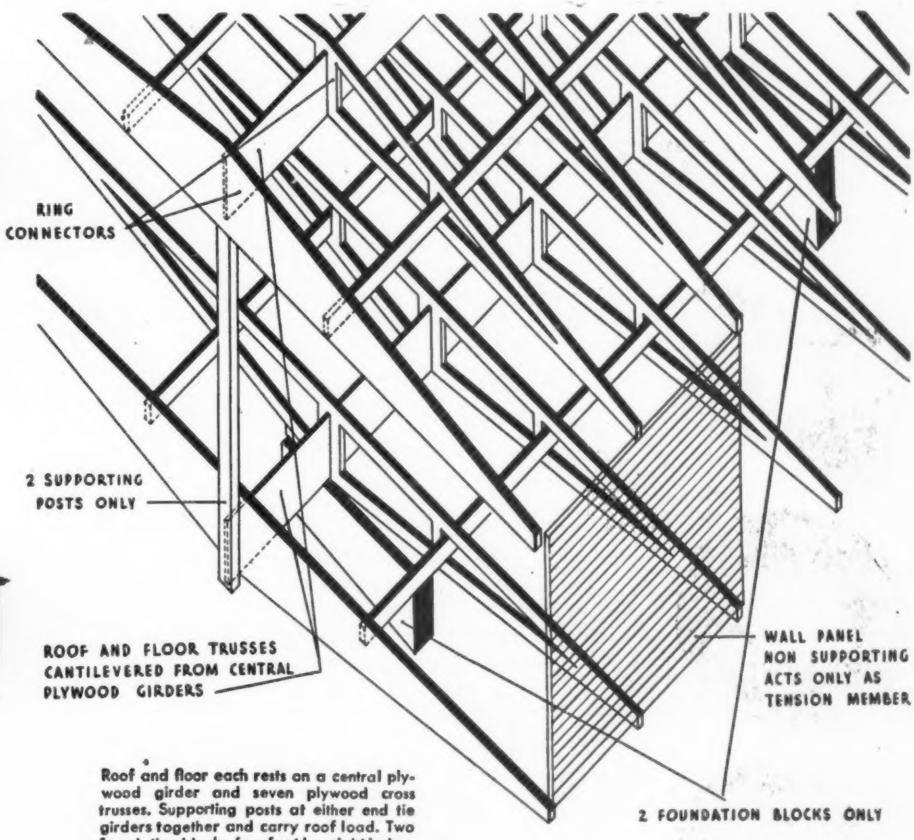
To save weight, gain production economies and add new notes of color and style, many of the house's fittings and accessories would probably be molded from plastics.



Interior partitions might be omitted, completed later. As family grows, a second complete unit might be added. Actually this house allows greater flexibility than conventional custom building.



With its narrow foundations, two-way cantilevered form and plywood skin, "Plas-2-Point" house is reminiscent of modern aircraft. Six-room house for cold climate would weigh 3 to 4 tons.



Roof and floor each rests on a central plywood girder and seven plywood cross trusses. Supporting posts at either end tie girders together and carry roof load. Two foundation blocks, four feet by eight inches, provide anchorage. Outside walls serve as tension members and give structure rigidity.

$$lh=\frac{\pi}{4}(d_2^2-d_1^2)$$

Solving this for d_2,

$$d_2=\sqrt{\frac{4}{\pi}lh+d_1^2} \qquad (33)$$

Also assuming that adjacent coils touch, the number of turns n becomes

$$n=\frac{d_2-d_1}{2h} \qquad (34)$$

Substituting the value of d_2 given by Equation 33, the expression for n becomes

$$n=\frac{\sqrt{\frac{4}{\pi}lh+d_1^2}-d_1}{2h} \qquad (35)$$

It should be noted that if the spring is oiled, adjacent turns will be separated by the thickness of the oil film and this will introduce some error in the equation.

Considering the condition when the spring is unwound as indicated in *Fig.* 10, if n' be the number of turns of the unwound spring, and again neglecting the turns connecting the inside of the wound portion with the arbor,

$$n'=\frac{D_2-D_1}{2h} \qquad (36)$$

Also, as before, since the area of the wound portion must be equal to hl

$$hl=\frac{\pi}{4}(D_2^2-D_1^2) \qquad (37)$$

From this

$$D_1=\sqrt{D_2^2-\frac{4}{\pi}hl} \qquad (38)$$

Substituting Equation 38 in 36

$$n'=\frac{D_2-\sqrt{D_2^2-\frac{4}{\pi}hl}}{2h} \qquad (39)$$

The total number of turns N delivered by the spring in unwinding from the wound position of *Fig.* 9 to the unwound portion of *Fig.* 10 will be the difference between n and n'. Hence the number of turns delivered becomes:

$$N=n-n'=\frac{\sqrt{\frac{4}{\pi}lh+d_1^2}+\sqrt{D_2^2-\frac{4}{\pi}lh}-(D_2+d_1)}{2h} \qquad (40)$$

Since the turns connecting the wound part of the spring with the arbor or case are neglected in this derivation the results given by Equation 39 are somewhat high. To obtain more accurate results, the value of N should be multiplied with a correction factor k less than unity. Values

of this correction factor are dependent on the ratio m of drum area minus arbor area divided by spring area, where

$$m=\frac{\frac{\pi}{4}(D_2^2-d_1^2)}{lh} \qquad (41)$$

Values of k for various values of m as suggested by Wallace Barnes Co. (6) are given in the accompanying table.

Values of k for Various Values of m

m	5	4	3	2	1.5
k	.672	.702	.739	.796	.85

It is seen that for values of m between 5 and 1.5 a reduction in number of turns below that calculated from Equation 40 of from 15 to 33 per cent may be expected.

Large Arbor Reduces Stresses

To avoid excessive stress concentration due to curvature effects, the arbor diameter is usually made around 15 to 25 times the strip thickness.

EXAMPLE: A spiral spring is wound from a strip ¾-inch wide, .015-inch thick and 100 inches long. The arbor diameter is ¾-inch and the inner diameter of the case 2¼ inches. The problem is to find the number of turns delivered from the solid to the free condition. Thus $h=.015$, $l=100$, $D_2=2.25$, $d_1=.375$.

From Equation 41

$$m=\frac{\frac{\pi}{4}[(2.25)^2-(.375)^2]}{.015\times 100}=2.58$$

From the table, by interpolation for $m=2.58$, $k=.76$.

Using the given values of h, l, D_2 and d_1 in Equation 40 the calculated value of N becomes 19.6 turns. This must be multiplied by the correction factor $k=.76$ which yields a value $19.6\times.76=14.9$ turns for the number of turns delivered.

Where a spiral spring has a large number of turns the equations for calculating stress and deflection become simple provided the coils do not come in contact during deflection. Where the number of turns is small and the outer end is clamped the peak moment and deflection may be calculated by means of the curves given.

Where the spring is wound tightly, as in the case of the mainspring of a watch, the relatively simple expressions given facilitate calculation of the turns delivered.

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Does Your Numbering System Need Revamping?

(*Continued from Page* 116)

"N" or "B" depending on whether the parts were made of cast iron or cast brass.

In many instances parts are used interchangeably on numerous instruments, in which case there is no immediate need for an indication of the instrument on which such parts are used. In other cases where parts are used mainly on a specific instrument, it is often of advantage to know the instrument on which they are used. This facility is easily provided when desired by prefixing the part or subassembly number with the key number of the instrument, such as 36R, taken from its catalog number. The part or subassembly number proper is not basically changed in any respect by the addition of the key number prefix since it still represents the same part or subassembly regardless of the presence or absence of the prefix. Furthermore a part which carries the prefix of a given instrument is not restricted for exclusive use on that instrument. If such a part, carrying a prefix, is later desired for use on another instrument, it may readily be so used, the prefix being retained, thus indicating the first use, or it may be removed by change if more appropriate.

Examples Show Use of Prefixes

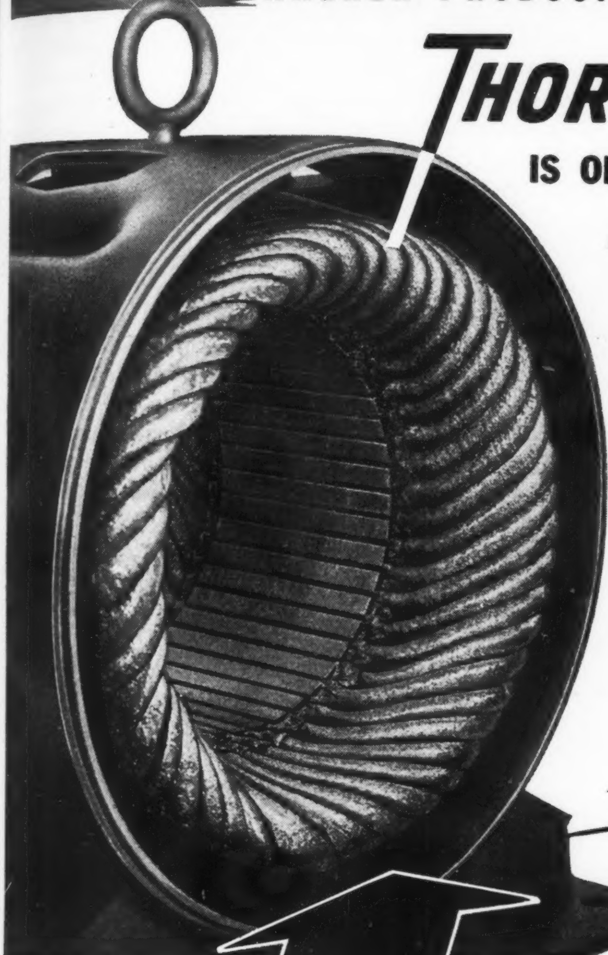
Some parts used on numerous instruments in the same group such as industrial thermometers but not used on instruments of other groups may to advantage carry as a prefix the first letter symbol of the group such as "E", omitting the preceding numerals. Such a part would at once be recognized as being used throughout the industrial thermometer line. Examples of part and subassembly numbers with prefixes indicating the instruments or groups on which they are used are outlined as follows:

36R15P37Y	Spider for Self-Acting Controller (Casting)
36R15P37	Spider for Self-Acting Controller (Machined)
7R2P181	Case for Type P Controller
E2P144A	Black Case for 9-inch Industrial Thermometer

Tracings of all parts and subassemblies are filed by the respective "P" or "S" group numbers. Reference books containing prints of parts and subassemblies in each "P" and "S" group are maintained. If it is desired to locate a certain instrument case it is only necessary to look in the "2P" book. In similar manner, if a designer requires a link he can at once review all of the existing links by looking through the "13P" group, *Fig.* 1, and thus perhaps use one already in stock rather than design a new one that might be only slightly different. Great advantage accrues from this feature, both in convenience and actual saving.

It is true that good judgment must be used in naming parts as they are designed so that they may be assigned to appropriate classifications. This is equally true of subassemblies. New numbers as they are assigned are reviewed by designated men who from experience and training have a thorough knowledge of the theory and

WAGNER PRODUCTS SPEED VICTORY!



THOROUGH INSULATION

IS ONLY ONE OF THE MANY REASONS WHY

Wagner MOTORS

Stay on the job!

All Wagner motors are built to exacting specifications, and embody characteristics and features that give them long life, dependability and added protection against failure. Wagner engineers will not compromise on "good enough" insulation — all windings must be thoroughly insulated. This is only one of the many reasons why Wagner motors stay on the job.

The illustrations on this page show typical polyphase stator windings. The stator cores of all Wagner polyphase motors are well insulated, using special slot cells formed from tough fibrous material, cuffed on each end for extra strength. The coils and free ends are shaped to fit snugly into the slots so that there is no possibility of vibration and at the same time the windings are easily put into place. Heavy separators are used between the coils in the slot and inverted U-shaped cells fit over the tops of the coils under the slot wedges. The free ends of the windings are completely taped well into the slot cells, and heavy sheets of black varnished muslin are slipped between the coils of the various phases to insulate them from each other.

After the windings are in place, the stator is baked to remove all moisture, and while still hot it is immersed in a heavy insulating varnish. When the heated stator core is immersed in the much cooler varnish a suction is created which produces complete impregnation of the windings. The stator is immersed long enough so that the insulating varnish impregnates the innermost portions of the coils. The stator is then baked again until this coating is completely dried. It is then given another dipping and baking to insure complete impregnation and to provide an added moisture-resisting coating. Finally, the stator is sprayed with air-drying varnish, which not only provides further resistance to oil and moisture, but also gives the coils a glossy surface.

FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

WRITE FOR COMPLETE INFORMATION

Complete information on Wagner motors will be sent upon request. Wagner is a nation-wide organization with branches in twenty-nine principal cities. Each branch office is manned by trained field engineers ready to help you solve your motor-drive problems.

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ELECTRICAL AND AUTOMOTIVE PRODUCTS

purpose of the plan as well as an active interest in maintaining it at its best efficiency. It requires little guidance and is used constantly and fluently by newcomers after short training as well as by those of long experience. The ease with which a new employe becomes actively familiar with the operation of the system is of particular advantage, especially in times of exceptional industrial activity as at present.

Subassembly Numbers Serve for Accessories

Accessory Numbers: For those sales items which are regarded as auxiliary or accessory products such as relays, reducing valves, air filters, etc., as distinguished from principal instruments like recorders and controllers, the subassembly numbers constitute the catalog numbers. Many such accessory items are either sold separately or assembled into other products. It can be seen that it would be impractical and unnecessary to establish a separate catalog number when such product is already completely identified by the subassembly number which can at once serve both purposes. Examples of such accessory numbers are:

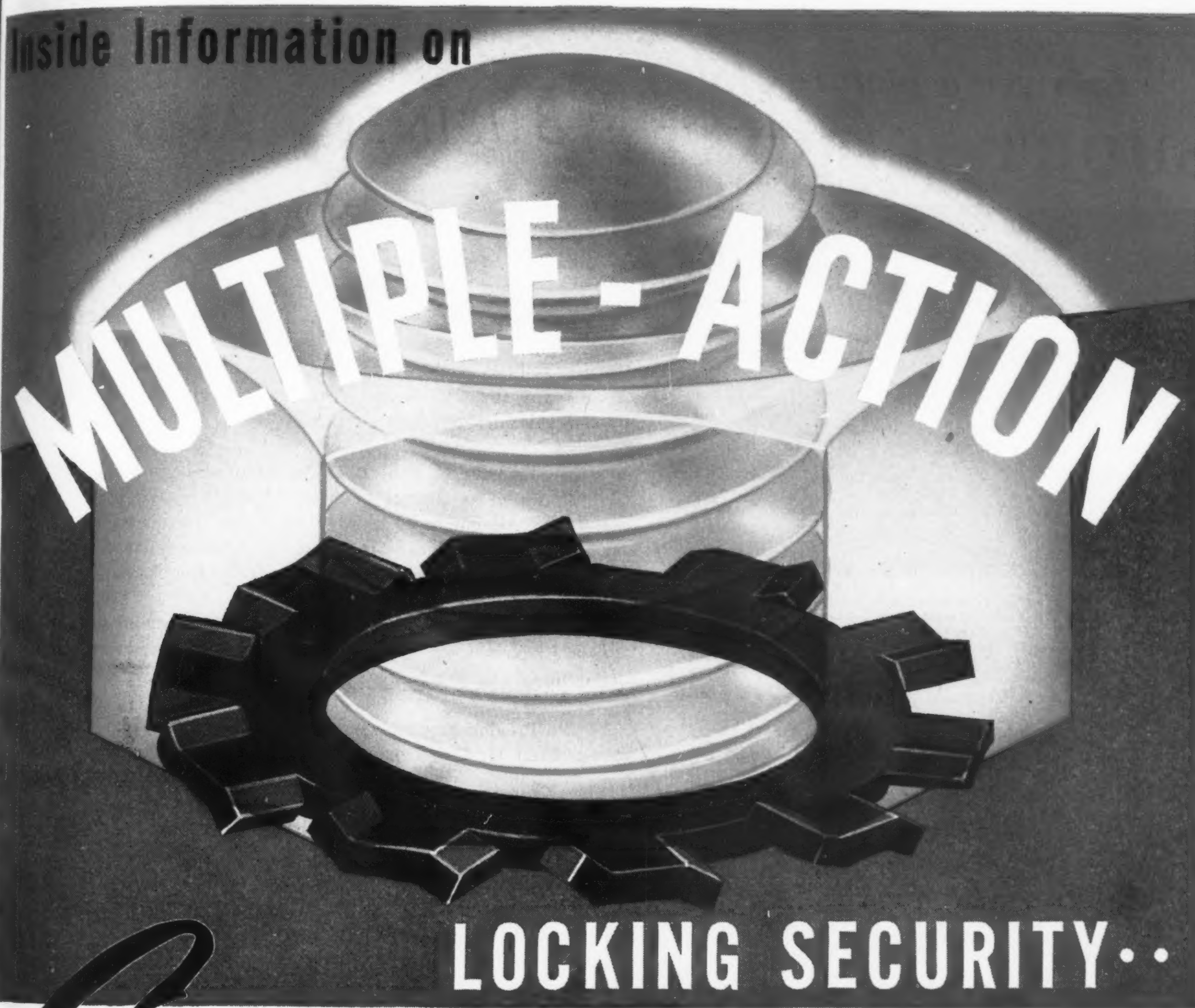
41S336	Booster Relay Air Valve
74S137	Electro-Pneumatic Pilot Valve
R89S17	Air Filter

Serial Numbers: Certain types of product are serially numbered to provide reference information such as date of manufacture, details of construction, etc., which is essential for identification in case of repairs or service. The key number of the catalog number again plays a useful part in that it, with the actuation letter followed by a consecutive number, comprises the serial number. It is at once evident that the serial number thus promptly provides a knowledge of the type of instrument to which it applies by its direct relation to the catalog number. Serial numbers never conflict with catalog numbers since the numerals following the letters either start above or are of a greater number of digits than those of catalog numbers. Examples of serial numbers are:

76JM5029	Mercury Recording Thermometer
120RV1421	Vapor Recording Controller
47KM632	Mercury 6-inch Dial Thermometer

It has been the purpose of this discussion to explain in simple and direct manner the nature and use of the unified number plan. While the treatment has not been exhaustive, it has been the endeavor to cover the principal points in the hope that design executives will find therein fruitful ideas which can be applied in their own organizations.

MANGANESE CONTENT of three NE steels has been slightly changed, according to a recent announcement by the American Iron and Steel Institute. For NE-9260, NE-9261 and NE-9262 the manganese content is now .70-1.00, instead of .75-1.00 as formerly. Latest list of NE steels appears in Machine Design's Directory of Materials in the October, 1943 issue, Pages 186 and 187.



EverLOCK WASHERS

THE WASHER THAT HAS THE EDGE

Listed on Government Ordnance Standard Prints BEAX 1-2-3-4-7-8
Shown on AN936 (Army-Navy Aeronautical Standard)

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★ ★ ★ Here's an X-ray view of an EverLOCK Washer at work. Its twenty wide chisel edges—forced into both the nut and the work by powerful spring tension—provide locking security that defies vibration, strain, expansion or contraction. This powerful flexing action on the full width of biting chisel edges is available only in EverLOCK Washers.

EverLOCK Washers are as economical to use as they are dependable in use. A half turn, or less, locks them securely. This permits important savings in assembly time . . . guards against stretching of bolts and screws and the distortion of threaded parts.

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BUSINESS AND SALES BRIEFS

ELECTION of T. W. Pennington as vice president in charge of sales of Jessop Steel Co., Washington, Pa., has been announced. Mr. Pennington has been with the company since 1933, and prior to his appointment served as general sales manager of the company.

♦

Transfer of Paul E. Floyd from Washington to his former position as district manager in the Chicago branch office of the Allegheny Ludlum Steel Corp. has been effected. For more than a year Mr. Floyd has been connected with the iron and steel branch of the War Production Board.

♦

An addition to its present plant is being made by Peerless Electric Co., 1401 West Market street, Warren, O., to increase its productive capacity.

♦

Previously connected with Timken Steel & Tube division, Fred H. Currie has been appointed manager of sales for the Pacific coast, Copperweld Steel Co., Warren, O. He will handle the complete line for Copperweld, and will have his offices at 403 West Eighth street, Los Angeles.

♦

Former manager of the North Pacific district for Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., David M. Salsbury has been appointed general manager of the Westinghouse Electric Supply Co., New York.

♦

Formerly representing the Brown Instrument Co., Philadelphia, in New York, Buffalo, Cleveland and Pittsburgh, as branch manager, W. H. Steinkamp has been made assistant general sales manager of the company.

♦

With headquarters in New York, John Gordon Bell will represent Follansbee Steel Corp. as district sales manager for the metropolitan New York and New England areas. He formerly had been connected with the Cleveland office of Jones & Laughlin Steel Corp.

♦

Owen L. Holland has been appointed Chicago district manager, welding division, Metal & Thermit Corp., New York. He previously had been associated with Hollup Corp. as general sales manager and with the WPB as chief of the welding, electroplating and equipment branch.

♦

New offices of the Bardco Mfg. & Sales Co., in Washington, D. C., have been opened. Under the supervision of James G. Goodwillie, sales engineer, the office is located at 606 Barr Building.

♦

Announcement has been made by Cutler-Hammer Inc., Milwaukee, of the appointment of W. E. Addicks as manager of the company's New York district office. Mr. Addicks formerly was in charge of the Boston sales office.

♦

In his new position as special mill representative for Lukens Steel Co. and its subsidiaries, D. Earl McElroy will act in a liaison capacity between the Lukens companies and C. T. Hansen & Co., Pacific coast sales representatives, with offices at 423-424 Russ building, 235 Montgomery street, San Fran-


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PAYS NO "DUTIES"
... when it travels on
WHITNEY CHAINS
Power travels straight through from prime mover to job, on Whitney precision-built Roller Chains. For Whitney design is utmost protection against friction-loss and slippage, which mean lost production ... and against damage from shock and overload. Then Whitney alloy-armored steels and exclusive manufacturing methods ... these are extra sureties of longer life in harder wartime service. That's why so many key war plants have made Whitney Chains their drives for Victory ... and why it will pay *you* to specify Whitney on every machine you build or buy.
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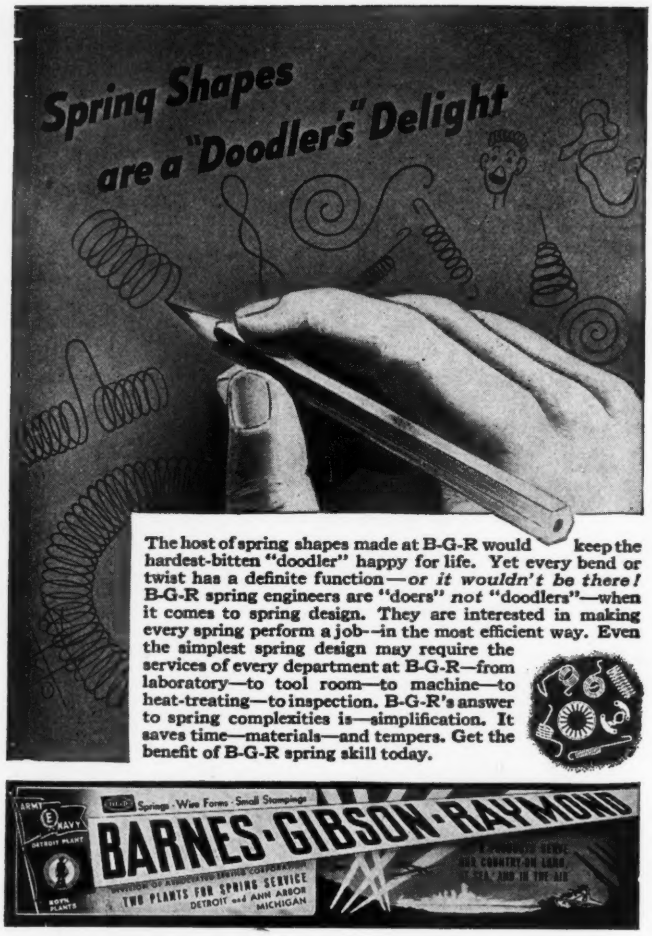

cisco 4; 628 Security building, 530 West Sixth street, Los Angeles 14; and 6115-16-17 Arcade building, 1319 Second avenue, Seattle 1.

♦

Connected with the foundry industry for many years, C. A. Hartman has joined the metallurgical and engineering service staff of the Meehanite Metal Corp., Pershing building, New Rochelle, N. Y.

♦

Offices in Cleveland on the twenty-third floor of Terminal Tower building, have been opened by Dow Chemical Co., to serve Cleveland, Pittsburgh, Buffalo, Toledo, Cincinnati, Dayton, Columbus, Akron and Detroit. D. T. Wellman, formerly of the sales department at Midland, Mich., will head the Cleveland office.

♦

With the company since 1932 as vice president and sales manager, James J. Nelson has been appointed general manager of Cramp Brass & Iron Foundries division of Baldwin Locomotive Works, Philadelphia.

♦

Completion of a new plant to make centrifugally-cast alloy castings for aircraft and other machines has been announced by The Cooper Alloy Foundry Co., Hillside, N. J. The new plant has approximately 17,000 square feet of floor space which increases the company's ability to make castings by the vertical centrifugal-casting method, making possible substitution of alloy castings for forgings, etc.

♦

Appointment has been announced by Trico Fuse Mfg. Co., Milwaukee, of the Southeast Engineering Co., 2065 Post street, Jacksonville 1, Fla., as representatives for the complete line of oilers, fuses, clamps for fuse clips, etc., in the states of Florida, Georgia and Alabama. The line will be represented under the supervision of Frank Gillooly.

♦

In charge of advertising and sales promotion for Lukens Steel Co. and subsidiaries since 1935, George M. Gillen has been appointed assistant manager of the combined sales of Lukens and its subsidiaries. In his new capacity Mr. Gillen will be concerned with the coordination of the sales departments and sales programs of the By-Products Steel Corp. and Lukenweld Inc., in addition to Lukens Steel Co.

♦

All business departments of Clarostat Mfg. Co. Inc., heretofore spread out in three plants are being consolidated at its new general offices located at 130 Clinton street, Brooklyn. Recent expansion has necessitated larger quarters for the company's offices.

♦

Change in name of the Pump Engineering Service Corp., 11610 Euclid avenue, Cleveland, has been made to PESCO Products Co. Present personnel and the firm's affiliation with Borg-Warner, the parent company, will remain the same. It was explained that PESCO is the tradename used for aircraft pumps and accessories manufactured by the company, and it is better known and more widely used within the industry.

♦

Judson P. Bowen has recently joined Penn Electric Switch Co., Goshen, Ind., as manager of the company's Atlanta branch located at 36 Fifth street, Northwest. He succeeds N. E. Jennison who has been transferred to the factory to assume new duties in the research laboratory.

♦

At 135 Cedar street, New York, will be the new headquarters of The Metallizing Co. of America, for its sales and service operations in that area. The building is a complete operating unit with development and test laboratories, warehouse

BEFORE MAN HAD WINGS

Illustration shows the first "aviation" patent granted in 1889 to one R. J. Spaulding by the U. S. Patent Office.

Back in 1889 when the first U. S. patents covering a flying machine were granted, machine building was a matter of cut and fit. There were no production problems. There was no production.

Modern-day requirements demand the ultimate in intelligent planning, designing, engineering, equipment facilities and production in order to compete in today's markets.

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Our experience of over forty years covers a broad range of manufacturing from close tolerance precision aviation parts to giant 16-ton portable stone crushing plants.

If you have a machine to market that requires the professional finishing touch, plus low cost manufacturing facilities, let our engineers discuss these problems with you. A request for consultation implies no obligation.

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UNIVERSAL ENGINEERING CORP.

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for metallizing guns, equipment, parts and wire, and general service departments. V. A. Cook will be in charge of eastern operations. The company also maintains general offices at 1330 West Congress street, Chicago, in addition to 22 strategically located engineering sales offices.

♦

Robert H. McCracken has been appointed manager of combined sales of the Boston office of Lukens Steel Co. and its subsidiaries, By-Products Steel Corp. and Lukenweld, Inc. Mr. McCracken, who formerly was associated with Central Iron & Steel Co., will be located at 131 State street, Boston 9.

♦

Formerly director of physical metallurgy at Washington State college, Herluf Nielson has joined Kinney Aluminum Co., Los Angeles, as chief metallurgist in charge of the technical department.

♦

Establishment of a sales research division to investigate new markets for Hercules Powder Co. has been announced. Dr. John H. Long will be in charge of the new division.

♦

With offices at 1526 South Olive street, Los Angeles, S. R. Kallenbaugh will act as West Coast district manager of the Steel and Tubes division, Timken Roller Bearing Co., Canton, O. Prior to his appointment Mr. Kallenbaugh was metallurgical representative for the company in Cleveland and Detroit.

♦

J. S. Wise has been appointed West Coast representative of the Aircraft Screw Products Co. Inc., L. I., N. Y., manufacturer of the "Aero-Thread" screw thread system. His offices will be located in the Title Guarantee building, Los Angeles.

♦

Formerly district sales manager for The Air-Maze Corp., Cleveland, on the West Coast, Jules Gratiot has been appointed sales manager.

♦

Associated with Bliss & Laughlin Inc., for the past seven years, J. Stanley McCord has been made sales manager of the eastern division of the company, with headquarters at Buffalo. Mr. McCord prior to his appointment was district manager of the Philadelphia office. John O. Hoover succeeds him as district manager at this office.

♦

Another distributor has been added to those for The Frederick Post Co., Chicago. It is the 20th Century Blueprint Co., 344 Bush street, San Francisco, which will handle the complete line of Post drafting materials, blueprint paper and kindred materials.

♦

Appointment of Howard W. Bennett as manager of the specialty division of General Electric company's electronics department has been announced. Mr. Bennett will be responsible for the engineering, manufacturing and sales operation of that division.

♦

Without change in management or personnel, the Ault & Wiborg Corp., a subsidiary of Interchemical Corp., recently became the Ault & Wiborg division of Interchemical Corp.

♦

Executive offices, sales, engineering, purchasing departments and technical laboratories of Advance Pressure Castings Inc. now are located at 894 Manhattan avenue, Brooklyn 22. The plant remains at its old location at 34-48 North Fifteenth street, Brooklyn 22. Appointment of George A. Meyer as general sales manager of the company was recently announced.

♦

Timken Roller Bearing Co. has announced the appointment of Whitley B. Moore as director of sales for all divisions of

Man, that's a smooth prime coat...

"SPEC" COATING

With a Distinct Egyptian PLUS

Every specification finish we make meets Government requirements to the letter . . . but that's only one point. There's a *plus* in an Egyptian "spec" finish, an *extra value,* which shows up in handling and in results.

• **AXS 946** •

For example AXS 946, a rust inhibiting primer for a wide list of ordnance items...

Brushed, sprayed or dipped, it covers bare metal with an extra-smooth, red-brown, corrosion-resistant coat which takes the final finish beautifully. Dries evenly and quickly.

For your products today — and tomorrow — an Egyptian Finish offers important plus value.

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EGYPTIAN FINISHES

EGYPTIAN

SUPERIOR FINISHES

the company, including industrial, automotive, railroad, service sales, steel and tube, and rock bit. He is being succeeded in his present position of general manager of sales of the Timken Steel and Tube division by C. H. McCollam.

♦

Transfer of F. J. Walton from Chicago to Los Angeles as West Coast representative has been announced by Rustless Iron & Steel Corp.

♦

Formerly assistant sales manager, Don Switzer has been made sales manager of Federal Mogul service division, Federal Mogul Corp.

♦

Thomas W. Pettus, formerly sales manager of National Bearing Metals Corp., St. Louis, has been advanced to vice president in charge of sales.

♦

A large extrusion plant for producing aluminum and magnesium tubes, shapes and rods will be equipped and operated for DPC by Phelps Dodge Copper Corp.

♦

An announcement recently has been made by Sherwin-Williams Co., Cleveland—that of Dr. Robert F. Ruthruff as director of research. Before joining Sherwin-Williams in 1939 Dr. Ruthruff was associated with E. I. du Pont de Nemours & Co., Standard Oil Co. of Indiana, Chicago, and M. W. Kellogg Co., New York.

♦

Thomas R. Coffee has been made manager of sales for the Wisconsin and Minnesota territories for Globe Steel Tubes Co., Milwaukee.

MEETINGS AND EXPOSITIONS

Nov. 8-9—

Society of the Plastics Industry. Fall meeting to be held at Waldorf-Astoria hotel, New York. Additional information may be obtained from the society at 295 Madison avenue, New York 17.

Nov. 10—

Society of Automotive Engineers. National Meeting on Materials—War and Postwar, sponsored by the Passenger-Car Activity, and Truck and Bus Activity divisions in cooperation with the Cleveland section, to be held at Hotel Carter, Cleveland. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary.

Nov. 15-16—

American Institute of Chemical Engineers. Meeting to be held in Pittsburgh. Additional information may be obtained from the American Institute of Chemical Engineers, 29 West Thirty-ninth street, New York.

Nov. 29-Dec. 3—

American Society of Mechanical Engineers. Annual meeting to be held in New York. C. E. Davies, 29 West Thirty-ninth street, New York, is secretary.

Dec. 6-11—

Exposition of Chemical Industries. Nineteenth exposition to be held at Madison Square Gardens, New York. Exposition under management of International Exposition Co., Grand Central Palace, New York. Charles F. Roth is president.

Jan. 10-14, 1944—

Society of Automotive Engineers. Annual meeting and engineering display to be held at Book-Cadillac hotel, Detroit. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary.

NEW MACHINES—

And the Companies Behind Them

(For illustrations of other outstanding machinery, see Pages 148, 149)

Air Conditioning

Evaporative condenser with built-in air filters, Drayer & Hanson Inc., Los Angeles.

Armament

Shell-box end and cover making machine, Food Machinery Corp., Riverside, Calif.

Hydraulic testing machine for parachute webs, Riehle Testing Machine Div., American Machine & Metals Inc., East Moline, Ill.

Mobile oil reclaimer, Youngstown Miller Co., Sandusky, O.

Aircraft piston wrist-pin hole counterboring machine, Snyder Tool & Engineering Co., Detroit.

Excavating

Tilt dozer, R. G. Le Tourneau Inc., Peoria, Ill.

Tractor sweeper, W. E. Grace Mfg. Co., Dallas, Tex.

*Cable dozer, The Heil Co., Milwaukee.

Self-propelled drilling unit, The Buda Co., Harvey, Ill.

Industrial

*Pneumatic drill, The Aro Equipment Co., Bryan, O.

Spinner-riveter, Airflex Equipment Co., Detroit.

Inspection car, The Buda Co., Harvey, Ill.

Electronic generator, Communication Measurements Laboratory, New York.

Riveting machine gun, R. Decat, Elmhurst, L. I., N. Y.

Wire, cable, cord, rope and paper wind-up machine, Industrial Oven Engineering Co., Cleveland.

Screw, bolt and rivet-sorting machine, Tubin Engineering & Mfg. Co., Los Angeles.

All-purpose fluid cooler, Gray-Mills Co., Chicago.

Hydrogen purifier, Eisler Engineering Co., Newark, N. J.

Turbine reduction units, Cone Drive Div., Michigan Tool Co., Detroit.

Air compressor, Sullivan Machinery Co., Michigan City, Ind.

Photoelectric control for measuring density of transparent materials, Photoswitch Inc., Cambridge, Mass.

Gas-electric power unit, Ready Power Co., Detroit.

Metalworking

25-inch hydraulic crank pin grinder, Landis Tool Co., Waynesboro, Pa.

12-inch hydraulic slotter, Rockford Machine Tool Co., Rockford, Ill.

Vertical miller, Kent-Owens Machine Co., Toledo, O.

Universal tool grinder, K. O. Lee Co., Aberdeen, S. D.

Hypro frog and switch planer, Cincinnati Planer Co., Cincinnati.

No. 4 fine pitch gear shaving machine, Fellows Gear Shaper Co., Springfield, Vt.

Tool grinder, Whipple Mfg. Co., Spirit Lake, Ia.

*Automatic profile miller, Earl A. Thompson Mfg. Co., Ferndale, Mich.

*Magnetic polishing lathe, The Lima Electric Motor Co., Lima, O.

*Metal piercing press, Dayton Rogers Mfg. Co., Minneapolis.

*Cut-off machine, The Bridgeport Safety Emery Wheel Co. Inc., Bridgeport, Conn.

*Hydraulic 3-way boring machine, Le Maire Tool & Mfg. Co., Dearborn, Mich.

Tap grinder, Edward Blake Co., Newton Centre, Mass.

Vertical bench milling machine, Benchmaster Mfg. Co., Los Angeles.

Portable hydraulic bending machine, Wallace Supplies Mfg. Co., Chicago.

Tap reconditioner, Detroit Tap & Tool Co., Detroit.

Hydraulic press, Colonial Broach Co., Detroit.

Cutter and tool grinder, Covel Mfg. Co., Benton Harbor, Mich.

Double action press, Lake Erie Engineering Corp., Buffalo.

Hydraulic precision thread rolling machine, National Electric Welding Machine Co., Bay City, Mich.

Office

Comptometer, Felt & Tarrant Mfg. Co., Chicago.

Welding

Bench-type duplex-jaw spot welder, Eisler Engineering Co., Newark, N. J.

Heavy-duty welder, Allis-Chalmers Mfg. Co., Milwaukee.

Manually-operated welder, Glenn-Roberts Co., Oakland, Calif.

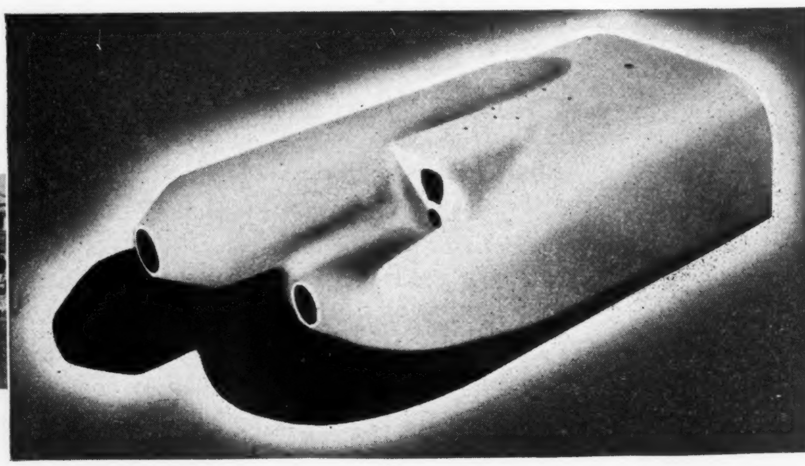
Woodworking

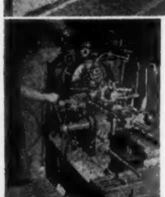
*Thickness planer, Boice Crane Co., Toledo, O.

Portable type radial saw, De Walt Corp., Lancaster, Pa.

Spindle sander, Boice Crane Co., Toledo, O.

*Illustrated in pictorial spread, Pages 148, 149.





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4660

Auxiliary Points

(*Concluded from Page* 123)

$$A_b = A_a + \!\!\rightarrow A^n_{ba} + \!\!\rightarrow A^t_{ba} \quad \ldots \quad (18)$$

$$A_c = A_d + \!\!\rightarrow A^n_{cd} + \!\!\rightarrow A^t_{cd} \quad \ldots \quad (19)$$

$$A_c = A^n_c + \!\!\rightarrow A^t_c \quad \ldots \quad (20)$$

The complete acceleration polygon is shown in *Fig.* 1*d*.

Selection of the auxiliary point is governed by the necessity of having a particular point for which the velocity can be obtained from the conditions known. As the floating member is the one which is difficult to define, the auxiliary point is located on the floating member, or an extension of the floating member. The particular point selected must be one which will give, on the polygon, vectors which coincide in direction with the corresponding vectors of known points. Such a point will be at an intersection of a line through joints of the members connected to the floating link. Thus in *Figs*. 2 and 3 the point M_1 is at the intersection of link 6 (the link 6 is in effect the line from center O_{46} to the center O_{16} at infinity, perpendicular to the direction of motion) and the extension of member 3. In *Fig*. 3 the member 3 is in effect the line through O_{23} to the instantaneous center O_{34} at infinity.

In each instance the velocity of M_1 may be obtained from the simultaneous equations

$$V_{m_1} = V_c + \!\!\rightarrow V_{m_1c}$$

and

$$V_{m_1} = V_a + \!\!\rightarrow V_{m_1a}$$

In each mechanism V_a and V_c are known in direction and magnitude, and V_{m_1c} and V_{m_1a} are known in direction.

Practical Problem Illustrates Method

An interesting, practical problem requiring the use of the auxiliary point and of Coriolis' law* for its acceleration solution is the mechanism for actuating a shaker conveyor made by the Goodman Manufacturing Co., *Fig.* 4. A double slider-crank mechanism shown schematically in *Fig.* 5*a* is driven at a uniform angular velocity by crank 2. A short reciprocating motion is imparted to the slider 5, which actuates the conveyor. Selection of the *two* necessary auxiliary points *M* and *N* is shown in *Fig.* 5*a*, while the velocity and acceleration polygons are shown in *Fig.* 5*b*, and 5*c*. Notice that the influence of the Coriolis' compound supplementary acceleration is appreciable.

To aid in the solution of problems as involved as this a table such as that shown beneath *Fig.* 5 may be set up, indicating the steps in logical order and the necessary equations. When this has been done and the solution for one position of the mechanism has been worked out it should be possible to delegate the job of analyzing the accelerations for a complete cycle of positions.

*See "How Acceleration Analysis Can Be Improved", by A. S. Hall and E. S. Ault, Machine Design, Feb., 1943, Page 100, and March 1943, Page 90.